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FIRE'S INFLUENCE ON WILDLIFE HABITAT ON THE BRIDGER-TETON NATIONAL FOREST, WYOMING

VOLUME II -- CHANGES AND CAUSES, MANAGEMENT IMPLICATIONS

George E. Gruell

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RESEARCH SUMMARY

This publication is volume II of two volumes on plant succession and wildlife habitat condition and trend on the Bridger-Teton National Forest in the Jackson Hole region of Wyoming. It is primarily intended for land managers, resource specialists, and the academic community.

Volume II discusses the "why" behind changes covered in the photo record provided in volume I. The analysis covers broad plant communities including conifer, aspen, willow, sagebrush, deciduous shrub, half-shrub, and tall forb. Also included are watersheds and stream courses.

The study area has experienced succession to conifers and sagebrush accompanied by buildup of heavy fuels, loss of understory plants, and a reduction in carrying capacity for wildlife. Prescribed fire and timber harvests in areas of good potential are the most practical means of improving wildlife habitat and reducing heavy fuels. The influence of these vegetative management techniques on wildlife is reviewed. The author concludes that fire must be integrated along with timber management into long-term land management plans.

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INTRODUCTION

This publication is volume II of two volumes on plant succession and wildlife habitat condition and trend on the Bridger-Teton National Forest in the Jackson Hole region of Wyoming. It is primarily intended for land managers, resource specialists, and the academic community. Volume I is largely pictorial, and intended for a wider audience, including nonprofessionals who have a high interest in the landscape.

Volume I compares photographs taken between 1872 and 1942 with 1968-1972 retakes. Photographs are preceded by a description of the study areas, including geology, topography, soils, climate, and vegetation. A brief history reviews highlights of early exploration and settlement. Insight into biotic and abiotic influences on the landscape is also provided. A knowledge of historical and ecological influences which shaped wildlife habitats of the Bridger-Teton National Forest prepare the reader for the photographs which comprise the body of the paper.

Eighty-five matched photographs are arranged in three geographical sections from north to south. Included is the Teton Wilderness and vicinity, the Gros Ventre Drainage, Jackson vicinity, and the Hoback Drainage. Elevational differences from 5,800 ft (1 768 m) to 12,165 ft (3 709 m) dictate a wide assortment of vegetation. Plants vary from alpine to cold desert species.

Photo captions highlight pertinent relationships including changes in each scene. Interpretations offered are mostly related to wildlife habitat. Also covered is information pertinent to fisheries, forestry, range, geology, soils, hydrology, fire management, and management of the visual resource. The role of fire, which was the primary driving force influencing vegetative development, is given special emphasis.

Changes in each geographical section in volume I are summarized in a concluding section. This discussion provides an overview of changes depicted in the photo record. The analysis covers broad plant communities, including conifer, aspen, willow, sagebrush, deciduous shrub, half-shrub, and tall forb; also included are watersheds and stream courses.

Volume II explains why successional changes occurred, in light of current understanding of biotic and abiotic influences. Included is material drawn from published and unpublished sources as well as observation on the Bridger-Teton National Forest and relevant studies done elsewhere.

Management implications are discussed in the context of existing land management classifications and ability of the land to produce vegetation. Some areas have a high potential, whereas in others, the potential is limited.

Reduced fire periodicity has resulted in widespread successional advances. This is reflected in heavy fuel buildup, loss of understory plants, and a reduction in carrying capacity for wildlife. Plant succession has also resulted in far-reaching influences on other fire-dependent systems.

Prescribed fire and timber harvests are recognized as the most viable means of improving wildlife habitat and reducing fuel buildup.

Benefits of habitat modification vary depending on the wildlife species and successional stage. Many wildlife species increase in early plant succession while others are displaced or eliminated until later succession.

It is concluded that because fire is a natural phenomenon that initiates many beneficial processes and because it should not be eliminated from the system, fire must be integrated along with timber management into long-term land management plans.

Readers with a deep or professional interest should have a copy of volume I while reading volume II. Volume I provides a map of the study area and maps of photo locations. Volume I also contains the "Plates" referred to in "Changes and Causes" in volume II. Lists of scientific and common names are given in volume I, appendix II.

CHANGES AND CAUSES

Conifers

Significant successional advances of conifers in the past 75 to 100 years appear to be closely tied to a reduction in fire frequency. In absence of fire, conifers have had an opportunity to increase. They are favored by being longer-lived than other plants and better adapted to the more productive sites. As a whole, greatest change in coniferous forests has occurred in lodgepole pine stands from valley floors to about 9,000 ft (2 744 m). Photo evidence, narratives, and fire scars suggest that much of this type was in early succession at the turn of the century. Today, trees are mostly 100 to 150 years old, and subalpine fir is often a principal component of the understory. Lodgepole pine stands above 9,000 ft (2 744 m) are generally older than at lower elevations. Two-hundred-year-old trees are common. At high elevations, lodgepole pine has been less susceptible to mountain pine beetle infestations. Fuel buildup has been slow and burning conditions less severe, so fires have been less frequent and less intense.

Most Douglas-fir stands are 100 to 125 years old on north and west exposures along the lower Gros Ventre River, in the Jackson vicinity south through the Grand Canyon of the Snake River, and along the lower Hoback River. Fallen fire-killed snags suggest that these localities were in advanced succession by 1870, with high fuel loading. Subsequent widespread burning in the 1870's, at a time when few white men frequented the region, resulted from a coincidence of ignition and extreme burning conditions. The even-aged stands that we see today resulted from these fires (plates 33, 66, 71). Although not readily apparent in the photographs, subalpine fir regeneration is common in these Douglas-fir stands, having been favored by the shaded environment.

Douglas-fir on southerly and easterly exposures and ridges, particularly on the north side of the Buffalo Fork River, are more variable in age. Fires appeared to be more frequent on these sites because of the drier environment that supported light fuels. Ground fires were recurrent as evidenced by fire scars and charred bark on these more scattered trees. Individual older trees that predominate today have persisted despite recurrent ground fires over the past 300 to 400 years (plate 24).

The spruce-fir forests of today are in late succession. Dominant Engelmann spruce are often between 200 and 300 years old. The understory is usually characterized by shade-tolerant subalpine fir. Wildfires in spruce-fir are more widely spaced because of the infrequent coincidence of severe burning conditions and an ignition source. Fire-scarred trees and the variable age structure of stands today attest to a history of low-intensity fires, which is the normal expectation in the moist environments characteristic of spruce-fir forest. Over the centuries, however, high-intensity fires resulted when heavy fuel loading, ignition, and extreme burning conditions coincided.

Engelmann and blue spruce in valleys and low elevation canyon bottoms appear to have burned more frequently because of drier conditions and more rapid fuel buildup. Most of these stands are currently in early succession (plates 11, 74).

Whitebark pine stands vary from those with 200- to 300-year-old trees and high mountain pine beetle mortality, as in upper Rodent Creek, to stands 90 years of age or less on the west slope of Big Game Ridge. The fire-free interval in whitebark pine stands appears to have been longer because of sparse fuel and fuel buildup. Fire behavior in this type apparently varied with tree density. Where trees were scattered, as on the west slope of Big Game Ridge, burning must have been largely by spotting from tree to tree because the sparse herbaceous cover could not carry fire very far. In closed stands, fires probably burned most of the trees, which resulted in even-aged young growth that today contrasts sharply with adjacent, older stands.

Though not readily apparent in current photos, dead trees are numerous in lodgepole stands below 9,000 ft (2 744 m). Most were killed in the 1950's and 1960's by the mountain pine beetle. This epidemic has largely run its course, but localized endemic infestations occur annually. At the height of the epidemic, a massive though largely unsuccessful attempt was made to control the beetle by spraying infested trees from the ground with the pesticide ethylene dibromide in a diesel carrier. In some areas, the infestation rate was slowed sufficiently to allow harvest of infested trees before excessive deforestation took place. Research by Roe and Amman (1970) and observations during this study indicated that mountain pine beetle epidemics resulted when lodgepole pine simultaneously became susceptible over wide areas. Epidemic infestations largely depend upon the presence of trees 10 inches (25 cm) d.b.h. and larger, with thick phloem (Amman and others 1977). Lodgepole pine regeneration following fires in the middle and latter 1800's apparently formed a contiguous food base, which allowed widespread proliferation of the beetle by the late 1950's. The mountain pine beetle, a food-limited insect, may not have been able to spread as extensively prior to settlement because of a fire-caused mosaic of younger aged trees, which confined infestations.

Mountain pine beetles also attack whitebark pine at high elevations. Affected trees are usually more than 150 years old and damage is restricted to scattered individual trees or small groups of trees. Older trees are recurrent targets and, in time, most succumb to the beetle. In pre-settlement times, fire inevitably followed the accumulative buildup of fuels and new trees regenerated.

Conifers are subject to many insects and diseases, but the only other insect presently causing conspicuous damage in the study area is the western spruce budworm (*Choristoneura occidentalis*). This insect prefers new foliage of Douglas-fir, subalpine fir, and spruce. Douglas-fir has suffered the most in recent years. Stands approaching 100 years old have been particularly hard hit in the Jackson locality. Defoliation over several consecutive years prevents seed crops and may kill trees, particularly those less than 10 inches (25 cm) in diameter.

Aspen and Cottonwood

The photographic record shows that young, dense stands of aspen were common in the late 1800's and early 1900's. Brandegee (1899) observed these young stands and pointed out that wildfires had influenced their distribution. Evidence of past fires in aspen stands can be seen today in the form of charred material in the soil, burned snags, and fire scars. Research has shown that fire stimulates aspen regeneration by killing parent stems and releasing food energy to root suckers (Schier 1975). Most of today's parent aspen stands in the study area regenerated after fire and coincident with high elk numbers (Gruell and Loope 1974). Houston (1973) arrived at a similar interpretation of aspen-fire-ungulate browsing relationships in the northern part of Yellowstone National Park. Apparently elk browsing was not heavy enough to suppress profuse suckering brought on by these early fires. It appears that the increased production of grasses, forbs, and shrubs following widespread fires buffered the browsing effects of ungulates on aspen. Successful regeneration of aspen following fires might have also coincided with a low in the elk population. It is unlikely, however, that aspen regeneration following fire always coincided with low elk numbers.

With some exceptions, aspen stands today, particularly on big game winter ranges, are either mature or deteriorating. Recurrent browsing has suppressed suckers, and regeneration during the twentieth century has been poor. Such deterioration is not unique to Jackson Hole (Schier 1975). Some aspen stands in Jackson Hole have regenerated without fire. Exceptions are the young stands on the 1934 Fall Creek-Munger Mountain and Taylor Creek-Mosquito Creek burns; the 1919 Jack Creek burn; small 1930 and 1932 Spread Creek burns; and localized areas where light ungulate browsing has allowed variable aspen regeneration without fire.

Most aspen are on sites where they are seral to conifers. Aspen were dominant during early succession, but with passing of time and a reduction in fire frequency they have been replaced by conifers. Very often only a few parent trees of a once-flourishing clone remain. Aspen regeneration in the shade of conifers has been minimal and completely suppressed by browsing where ungulates are numerous. Aspen also occupy relatively stable fire climax sites where they apparently have predominated for hundreds or possibly thousands of years. On these sites, periodic fires have rejuvenated clones and kept competing conifers out. Without fire, changes have resulted that largely depend upon the proximity of fire-intolerant species. Where aspen stands have deteriorated and conifers are close by, conifers have progressively invaded aspen stands.

Chokecherry and serviceberry are replacing deteriorated aspen stands on more mesic sites (plates 63, 69). These shrubs are reaching maximum growth potential in various localities near Jackson, along the Snake River south of Jackson and along the lower Hoback River where browsing is less intense. They also dominate some deteriorated aspen stands in other localities like Spread Creek, but heavy ungulate browsing has suppressed their growth.

Mountain big sagebrush has invaded many aspen stands in late successional stages on xeric sites. Generally, the few aspen suckers in these stands have been suppressed by wild ungulates. In some instances, however, light ungulate browsing has allowed aspen to outcompete mountain big sagebrush and regenerate the stands. With few exceptions, the density of successful aspen suckers is probably well below that which established the parent stands. Considering the high combustibility and fuel loading characteristic of the mountain big sagebrush-aspen community, wildfire was undoubtedly the dominant factor perpetuating aspen in presettlement times.

The frequent failure of deteriorating aspen clones to regenerate vegetatively by root suckers was investigated in Utah by Schier (1975). Roots of some deteriorated clones produced relatively few suckers, while roots of others produced the same or significantly more suckers than healthy clones. These suckers may develop into trees, but they are more often suppressed by hormones produced by the parent trees (apical dominance). Until apical dominance is broken by a major disturbance such as fire, cutting, or spraying that kills the parent trees, the stand tends to deteriorate. The absence of aspen suckers in clones where parent trees have died suggests significant loss of a viable root system in some clones.

Cottonwood appear to be declining in most stream-side areas. As a rule, stands were in varying stages of early succession when photographed before and after the turn of the century. Periodic wildfire often killed competing conifers and stimulated cottonwood regeneration. Today, Engelmann and blue spruce are the primary competing conifers. Where spruce density is low, cottonwood are holding their own; where spruce density is high, cottonwood are dying out (plate 74). Cottonwood has regenerated successfully on some depositional areas (plate 61). Growth has occurred on favorable sites (plate 57).

Willow

Excepting mountain big sagebrush, willows are the most widely distributed shrubs in the study area. Though still plentiful, willows are less abundant than they once were. Current distribution and condition of these important shrubs varies with site and location. Both losses and gains in willow distribution and density have occurred on flood plains. Losses appear to result from heavy browsing, moisture deficiencies resulting from competing vegetation, changes in the soil moisture regime resulting from stream channel changes, pathogen attacks, and lack of seedbed preparation and stimulation by fire. Patten (1968) and Houston (1976) arrived at similar interpretations in Yellowstone Park. Willows lost from stream channel changes are often compensated for by establishment of new shrubs in the sediments of old channels and in old beaver ponds. Willow has increased markedly in the alluvial sediments at the upper ends of Lower and Upper Slide Lakes.

Prior to the 1930's, willows on flood plains were large and their growth form had not been materially altered by the browsing of large numbers of wintering elk. Only during severe weather when deep crusted snow made preferred herbaceous forage unavailable did elk heavily browse willow and influence its growth form. Old timers refer to these severe periods as those when elk were "willered up." During intervening, less severe winters lighter browsing permitted willow to accumulate growth and maintain a large size. Utilization of willow by moose was light during this era because moose numbers were extremely low. By the late 1930's, willow on the Gros Ventre River flood plain showed the accumulative effects of browsing which Olson (1938, unpubl. ref.) attributed to elk.

Several photos of the Gros Ventre winter range show a marked reduction in willow height during the past 50 years. The earlier, taller stature of willow is also currently evidenced by the greater height of dead branches protruding above living material. Some appreciation of former conditions can be gained by viewing willow within the Goosewing exclosure which has been largely protected from ungulate browsing since 1960 (fig. 1).

The reduction in size of willow on flood plains is attributed primarily to moose, but elk and cattle have also contributed to the reduction. Between 1957 and 1969 winter utilization, as determined from measurement of tagged branches, varied from 47 to 98 percent. Blister canker (*Cryptomyces maximus*), a native fungus,

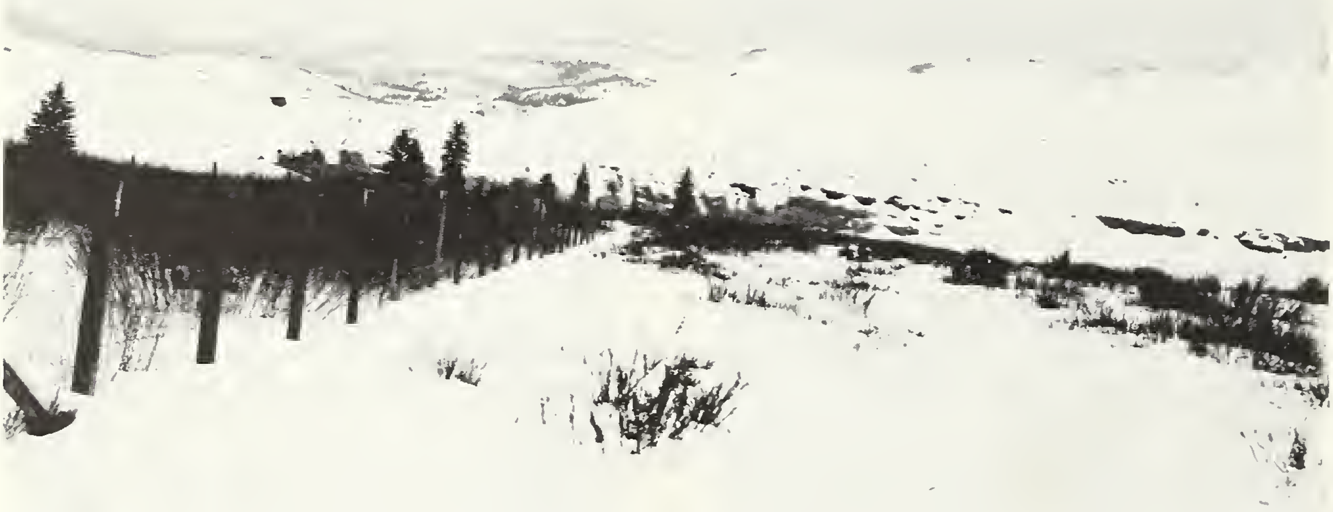


Figure 1.--Goosewing willow exclosure (fenced in 1960), February 6, 1969. Compare size of plants inside exclosure after 9 years protection with those outside, which have been browsed yearly for several decades.

has girdled older willow branches (Furniss and Krebill 1972), but its influence is not readily apparent when browsing levels are low because new growth quickly replaces the old, thereby screening it from view. This is evident on flood plains east of Jackson Lake and in the Hoback Basin where moose browsing is light. On the Gros Ventre winter range and other localities where browsing increased dramatically as the moose population expanded, new growth could not replace mature branches lost to blister canker. Repeated browsing of current growth eventually reduced the size of willows. Today, willow plants heavily used by moose on flood plains largely consist of only current year's growth; however, this growth commonly exceeds 24 inches (61 cm) because of the stimulating influence of browsing. In many localities heavy browsing has increased the quality as well as total amount of available forage, since the current year's growth contains less lignin and more crude protein than the older growth.

Changes in willow distribution and condition are evident also on canyon bottoms, benches, and mountain slopes where willows are associated with springs, seeps, and meadows. The loss of willow on these sites tends to be greater than on flood plains primarily because of less available soil moisture. Photos suggest that mountain big sagebrush and conifers are strong competitors on these areas. Long-term warming of the climate may also have contributed to the reduction in willow. The decline of willow has been further compounded by pathogen and insect attacks, browsing by native ungulates, late summer and fall utilization by cattle, and a reduction in fire frequency.

Changes in the appearance of willow on high-elevation mountain meadows and stream courses have been variable. Both gains and losses of the primary species, Wolf's willow, seem to have occurred. I have observed that Wolf's willow is killed back periodically by insects or pathogens. In Yellowstone Park the beetle (*Disconycha plurligata*) killed interior willow (Houston 1976). Losses from ungulate browsing at high elevations are not likely because of generally light utilization; however, summer utilization by moose and cattle has suppressed growth in given localities.

Photographic evidence, charcoal, and more recent burns demonstrate that willow communities, even though they occupy wet or moist sites, were periodically rejuvenated by wildfire. Scouler willow was a primary species affected. These fires usually burned under extremely dry conditions in the late summer and fall. Burning promotes sprouting, temporarily eliminates competition and allows establishment of new plants from seed (Lyon 1971).

Mountain Big Sagebrush

Of six species and subspecies of sagebrush in the study area, mountain big sagebrush is by far the most common. All references to sagebrush refer to this subspecies unless otherwise noted.

The photo record shows that, with few exceptions, sagebrush density was lower in earlier years than it is today. A nonsprouter, sagebrush is readily killed by fire (Blaisdell 1953). Charcoal in the soil and burned material on the surface indicate that this resulted from wildfires that periodically swept sagebrush communities. Wildfire did not always burn the entire landscape, however. Because of discontinuous fuels and other factors, including variations in fuel moisture, slope, and topography, some areas were left unburned at times. Such areas have changed little over the years (plates 49, 50 distance, 67, 82). Some sagebrush plants are now more than 130 years old.

Only three scenes suggest decreases in sagebrush (plates 2, 58, 79). The reduction in plate 2 may have been caused by a lack of snow cover and freezing, or the aroga moth (*Aroga websteri*), an insect that commonly kills sagebrush in the West. Losses in plate 79 apparently resulted from shading brought about by growth of Douglas-fir. The demise of sagebrush in plate 58 largely resulted from trampling by unnaturally high concentrations of elk that have been commonplace on feedgrounds where sagebrush cover was formerly heavy.

As a whole, a reduction in acres burned has allowed sagebrush to increase markedly in distribution and density throughout the area. Locally, heavy concentrations of cattle along driveways and at drift fences have also facilitated sagebrush increase (plates 37, 39, 62). The increase has apparently accelerated in the past 30 years in some localities outside cattle allotments (plate 68).

Insight into the rate of sagebrush establishment following fire is provided by several photo comparisons where the date of the fire has been reasonably established. Plates 28, 30-31, and 42 indicate only a few sagebrush plants 20-25 years after burning. Establishment was even slower in the foreground of plates 50 and 51, which apparently burned in 1872.

Sagebrush returns slowly on fine-textured soils with good potential for production of herbaceous species. This is demonstrated on a September 6, 1966, burn of 31 acres (13 ha) bordering the Buffalo Fork River where density of sagebrush seedlings was low 10 years later. Rapid re-establishment of sagebrush seems to occur on sandy or gravelly soils which are well suited for supporting sagebrush but have a poor potential for herbaceous plants. Maturing sagebrush plants were dense 11 years after a wildfire on granitic soils along the Sweetwater River outside the study area.

Fire intensity may have also influenced the rate of sagebrush re-establishment. Seedlings seemed more numerous when only 40 to 60 percent of the sagebrush was killed by herbicides (Johnson 1958). Cooler spring burns may cause a similar response because abundant seed sources remain from unburned sagebrush plants. In the sagebrush type, wildfires that burn under extreme conditions destroy sagebrush plants and aerial seed sources over considerable areas. Mueggler (1956) found that sagebrush seedling establishment following fire came from both aerial sources and viable seeds in the soil. Seedling establishment on the Breakneck Ridge burn of August 29, 1974, in the Gros Ventre River drainage indicate germination from residual seeds, since new seedlings are several hundred yards from the closest living sagebrush plants. Fall burning in Idaho resulted in about one-tenth the sagebrush plant density on burned compared to unburned range after 11 years. Most sagebrush seedlings became established the first year or two after burning before the grass stand thickened (Pechanec and others 1954).

The marked increase in sagebrush density throughout the study area has been accompanied by a decline of herbaceous species and deciduous shrubs. Past wildfires were instrumental in converting the sagebrush biomass into herbaceous plants and deciduous shrubs. Early photographs show good herbaceous cover on sites now dominated by sagebrush.

On the Snake River plains of Idaho, Pechanec and others (1954) found that perennial grasses and weeds (forbs) increased about 90 percent four years after late summer burning, and after 15 years production was still 33 percent above unburned range. Availability of herbaceous plants was greatly improved for livestock by the almost complete removal of sagebrush. Undesirable effects were the loss of one-half to two-thirds of the bitterbrush plants. Idaho fescue had not fully recovered after 11 years, while bitterbrush took 9 years to regain losses.

Observations of responses following a wildfire in the fall of 1966 immediately adjacent to plates 11 and 12 suggest that herbaceous production increased well above pre-burn levels 4 years after intense burning.

Lupine, checkermallow, pigweed, golden corydalis, fireweed, and lesser amounts of both pioneer and climax species predominated the first year after the 1974 Breakneck Ridge burn in the Gros Ventre River drainage. Vegetal production was markedly greater the second year after the burn due to the exceptional vigor and increased density of perennial grasses and forbs. Increased production apparently resulted from increases in available soil moisture and soil nutrients no longer utilized by sagebrush. Of particular importance is an expected increase in available nitrogen through microbial decomposition of the large volume of dead roots left after the fire. Complex organic compounds of nitrogen are converted to simple inorganic compounds that are available to higher plants. Accruals of available nitrogen can also be expected from nitrogen-fixing plants such as lupine, which often proliferates the first few years following a fire.

Third-year vegetative response on the Breakneck Ridge burn and a comparable 1974 prescribed burn on Burro Hill showed a continued increase in production, especially perennial grasses. Although poor spring moisture restricted optimum growth, total herbage was up because of accumulative plant growth and establishment of new plants.

Other Shrubs

Nearly all of the other shrubs found in the study area have the ability to regenerate vegetatively. Past attention has been directed almost entirely to four palatable species on ungulate winter ranges: serviceberry, chokecherry, bitterbrush, and rubber rabbitbrush. All are important forage plants. Centers of greatest use have been the lower Buffalo Fork River, in the Spread Creek vicinity, along the Gros Ventre River near Jackson, along the Snake River and Hoback River.

Photo comparisons on the Gros Ventre drainage show that serviceberry, chokecherry, and bitterbrush distribution has been extremely localized since settlement. Best development was and still is on the lower 6 miles of the river above the Forest boundary where the rocky soils are suited for supporting these species. Occurrence of chokecherry and serviceberry above this point is restricted to localized snowbank microsites and aspen communities. Bitterbrush occupies a few ridges and east-facing slopes. All three species usually have a hedged appearance due to persistent winter browsing. Growth has occurred on some sites where winter foraging by ungulates has declined (plate 28).

Rubber rabbitbrush is the only palatable shrub that is abundant on the Gros Ventre winter range. It is well adapted to the drier environments of the Gros Ventre region where it persists despite yearly removal of 75 to 95 percent of the current growth by elk. A prolific seeder, rubber rabbitbrush has become established on disturbed sites and has proliferated in areas burned or sprayed with the herbicide 2,4-D.

Chokecherry, serviceberry, and bitterbrush are more uniformly distributed on the Hoback winter range. Soils contain a high percentage of weathered shale over much of the area, and available soil moisture is good for the growth of these shrubs. Rubber rabbitbrush is also well represented throughout the area. The condition and trend of these shrubs are variable on the Hoback Range. In some localities, such as the Gilcrease site (plates 68, 69), and on the bench above the highway about 0.5 mile to the southeast (plate 70), shrubs have grown considerably in recent years. In the latter area, evidence of formerly hedged crowns are still exhibited by the dead branches within the shrub canopies. The change in growth form has largely resulted from reduced winter utilization by elk. Since 1960, the elk in this area have shifted from foraging on traditional winter ranges to depending primarily on feedgrounds operated by the Wyoming Game and Fish Commission. Elk use still occurs during open winters and in spring, but at levels well below those of former years when large numbers of elk free-ranged in this locality. Increased vehicle traffic over the years has also discouraged elk from frequenting some localities close to State Highway 187-189. This has resulted in reduced utilization and increased growth of shrubs (plate 71). Snow machine disturbance of elk has reduced utilization in other localities including the Gros Ventre River and its tributaries.

Utilization of palatable shrubs has been heavier on wind-blown ridges, south slopes, and near elk feedgrounds where concentrated use over many years has suppressed growth and maintained a hedged growth form. Some observers believe that hedged shrubs resulted from increased elk utilization brought on by the feeding program, but early photographs and reports clearly demonstrate that shrubs were uniformly hedged from the turn of the century through the 1950's. For example, at the Camp Creek exclosure 0.75 mile from the Camp Creek elk feedground, serviceberry, and bitterbrush were closely browsed in 1939 and 1942 before the annual feeding that began in 1960 (plates 72, 73). Shrubs outside the exclosure continued to be closely browsed and hedged in 1968. Lacking historical perspective, some investigators have concluded that the robust shrubs inside the exclosure represent the natural appearance of the shrub community prior to the establishment of the feedground. However, the exclosure merely demonstrates the potential for shrub growth on similar sites if ungulate browsing is excluded. A suppressed growth form from persistent browsing was the historical norm and will continue to be as long as elk and deer use the area.

Depending upon ungulate distribution, shrub condition on other wintering areas varies from robust growth comparable to the Gilcrease area to closely utilized plants like those outside the Camp Creek exclosure. Accumulative growth has occurred where elk have been drawn away to feedgrounds. Near feedgrounds, and where ungulates continue to have access to the range, shrubs are closely hedged.

Palatable shrubs are periodically defoliated by the Great Basin tent caterpiller (*Malacosoma fragile*). Bitterbrush is particularly affected. Usually only part of the crown is defoliated, and killed portions are eventually replaced by new growth. Less vigorous plants may die if heavy defoliation occurs during several consecutive years.

Shrub tolerance to various levels of defoliation was demonstrated in a 12-year study in Colorado (Shepard 1971). Clipping 40 to 60 percent of the current annual growth between July 15 and September 15 stimulated serviceberry, and no serviceberry plants died regardless of the severity of treatment (up to 100 percent) when clipped during this period. Clipping bitterbrush at a 60 percent level during the same time period produced more dead material than clips of 20 and 40 percent. Plants clipped 60 percent were also less vigorous and had fewer leaves and stems, making the foliage less dense. After 10 years of the 100 percent clip, bitterbrush plants had lost much foliage, stem density was reduced, and many stems were dead. This study demonstrated the high tolerance of serviceberry and bitterbrush to defoliation even during early summer when growth is still occurring, but the study did not simulate the effects of heavy browsing by wild ungulates, which usually occurs during the winter when shrubs are dormant.

Recent research has shown why shrubs have a high tolerance for defoliation. McConnell and Garrison (1966) found that nonstructural carbohydrates (food reserves) of bitterbrush were lowest in late June and early July and highest in mid-November. In Shepherd's Colorado study, replenishment of food reserves coincided with defoliation treatment. This allowed plants to maintain enough vigor to survive extreme defoliation, though they were in a deteriorated condition. Hormay (1970) points out that some food reserves are used to nourish shrubs during winter dormancy and to start growth in the spring. Food reserves are highest during the winter.

Garrison (1972) reviewed research on shrub physiology and arrived at what he termed a new and important conclusion:

> ...although trees store most of their carbohydrate above ground, the preponderance of carbohydrate storage in true shrubs seems to be in the rather small diameter portions of the roots and secondly in the old heavy materials of the tops. Browsing generally removes only the young portions of the crown and not the major carbohydrate storage areas of the shrub. This may in part account for the remarkable tolerance of many rangeland shrubs to foraging by big game and livestock.

The perpetuation of palatable shrubs on winter ranges in Jackson Hole is primarily by vegetative means. New plants of species discussed in this section become established either from branches or suckers produced by parent plants. Prostrate bitterbrush branches can root after contacting the soil. Chances for such rooting are enhanced on steep slopes by soil movement caused by ungulates. Rooted branches sometimes result in new plants when the branch from the parent plant dies. The larger crowns of bitterbrush plants apparent in plates 68 and 69 resulted from continued vegetative regeneration.

Characteristically, both chokecherry and serviceberry have increased their crown area by producing numerous basal suckers and by new stems developed from lateral roots. Very often the height of these plants is suppressed by recurrent browsing. Perpetuation of rubber rabbitbrush is assured by seed and vegetative means.

Regeneration of sprouting shrubs on presettlement Jackson Hole winter ranges was apparently influenced by widely spaced wildfires which stimulated new growth and allowed establishment of seedlings. Observations on recent burns indicate that some sprouting shrubs were killed where heat was intense, but most were only temporarily set back. The intense heat generated by late summer and fall burns concerns some range managers. Fire of this intensity not only removes sagebrush, but also kills herbaceous plants and some desirable sprouting shrubs. Although this process seems harsh, it has been repeated over the centuries to the long-term benefit of the biotic community. Less palatable species, including bush cinquefoil, are set back or killed, thereby making room for the establishment of more desirable species. Many of these reproduce by rhizomes, which allow them to rapidly invade unoccupied sites. A literature review by Wright (1972) showed that after 10 years very few shrubs showed any harmful effects from fire. Vogl (1965) noted that burns on savannahs increase the production as well as the palatability of shrubs.

The opportunity to interpret the influence of a fire on a Jackson Hole shrub community was afforded by a 1952 fall burn of about 12 acres (2.45 ha) near the Bryan Flat Ranger Station. In 1970, biomass and vigor of serviceberry, chokecherry, and bitterbrush within this burn was considerably above those plants outside the burn. Some bitterbrush plants which contained considerable dead material died following the 1952 burn. Phillips (1970 unpubl. ref.) concluded from studies of burns in Idaho that more bitterbrush has been lost from fire than any other cause. Some of the Idaho fires occurred in spring when plant food reserves were low. Sprouting was less (15 percent) following light spring burns than after fall burns (41 percent) when food storage was better. Based on a literature review, Wright and others (1979) concluded that fall burning was more detrimental to decumbent antelope bitterbrush than spring burning. Pechanec and others (1954) found that on the Snake River plains in Idaho, bitterbrush required 9 years to recover after a fall burn.

Shrubs in forest communities have deteriorated greatly because widespread succession toward closed-canopy coniferous forest has reduced sunlight and growing space needed by seral shrubs. These shrubs have become senescent, many have died, and those remaining are being replaced by shade-tolerant species such as grouse whortleberry, highbush huckleberry, and shinyleaf spiraea. The decrease in density of palatable shrubs with succession to forests has increased browsing pressure on those remaining, which often have less forage quality.

Before the appearance of European man, wildfire was the principal agent for rejuvenating seral shrub communities. Recurrent fires over the centuries created a mosaic of variable-aged burns where shrubs persisted until shaded out by conifers. A revealing example is pictured in plate 76 where the influence of an 1871 wildfire in Douglas-fir was still evidenced in 1920 by the predominance of shrubs. In Douglas-fir habitat types of the Intermountain region, fires favor shrubs, and they may dominate seral communities for 20 to 50 years (Mueggler 1965; Lyon 1969). Shrub responses following burning of lodgepole pine and spruce-fir communities vary by habitat type. Shrubs enhanced by fire include chokecherry, serviceberry, snowberry, Rocky Mountain maple, currant, russet buffaloberry, alder, bog birch, elderberry, bearberry honeysuckle, thimbleberry, Scouler willow, and snowbrush ceanothus.

The absence of fire can be particularly detrimental to Scouler willow, a large treelike shrub that affords nesting habitat for birds and forage for ungulates. This willow species is especially abundant after burning (Mueggler 1965; Leege 1969). Today in the Jackson Hole region it is largely restricted to a few areas that were burned in 1919 and 1934 or to forest openings where overstory competition is minimal. Only remnant and dead shrubs occur where forest succession has progressed (fig. 2).

The absence of fire from coniferous forest has perhaps had the most far-reaching effect on snowbrush ceanothus. Today, it is restricted to remnant stands and isolated plants within and on the margins of forest communities. Where still found, it is quite important to the diet of wild ungulates and furnishes cover and forage for small mammals and birds. Snowbrush ceanothus comprised much of the plant cover following the early fires pictured in plates 78 and 80, but today most plants are dead. Those still alive have only a fraction of their former canopy and are closely browsed. Brandegee (1899) commented that in 1897 snowbrush ceanothus was at times conspicuous on areas burned several years previously.

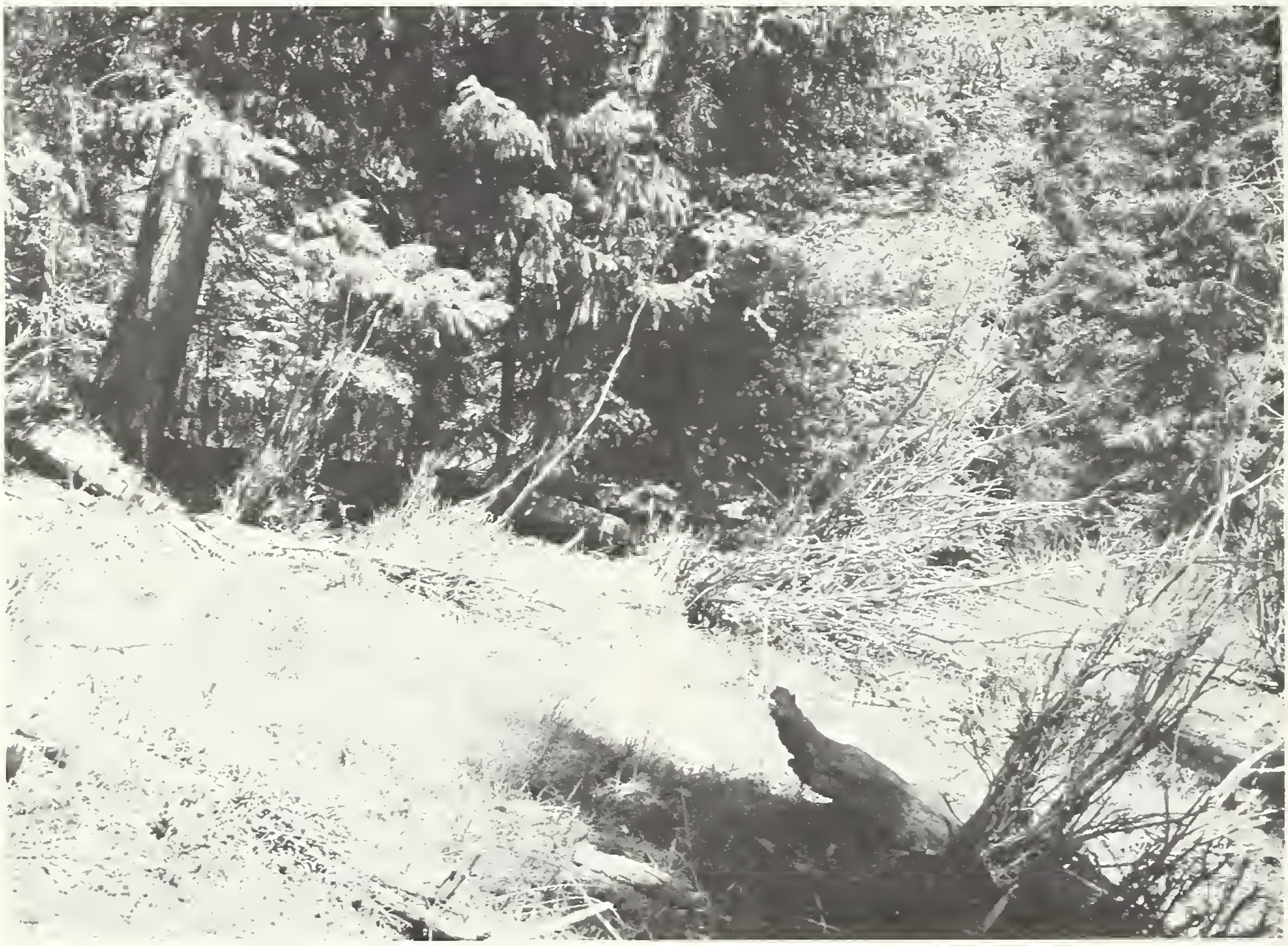


Figure 2.--Advanced succession in spruce-fir forest, May 22, 1969. Note remnant living and dead willows.

Snowbrush ceanothus seeds are virtually indestructible, lying in the soil for long periods (Schmautz 1970). Dormancy is broken by heat in excess of 140° followed by a cold period. Germination often results in a profusion of new plants where none were previously apparent. Gratkowski (1962) found 102,500 seeds per acre (253,175 seeds per ha) in mineral soil, and he estimated that germination of only 436 seeds per acre (1,077 seeds per ha) would produce a complete cover of mature ceanothus. Nitrogen-fixing symbiotic root nodules on snowbrush ceanothus aid ponderosa pine reproduction (Wahlenburg 1930). The development of new ceanothus plants following fire conceivably facilitates the growth and development of other species.

Half-Shrubs and Herbaceous Vegetation on Winter Ranges

The condition of half-shrubs, including Douglas rabbitbrush, winterfat, fringed sagebrush, and herbaceous species growing on ridge tops and south- and west-facing slopes have historically concerned resource managers. These sites are most prevalent in the Gros Ventre River drainage. Typical species besides the half-shrubs include several perennial grasses, Hoods phlox, pussytoes, eriogonum, and a mat locoweed. Interpretations of plant condition and trend on these sites have varied and have been complicated by yearly elk use. Graves and Nelson (1919) reported: "The condition of the winter feed on the slopes and ridges here constituting the winter range is excellent and should improve year by year." Two years later, Forest Service range inspectors J. W. Nelson and C. N. Woods differed in their interpretations during a joint inspection. Nelson believed that the exposed south slopes and wind-blown ridges, where vegetation was sparse, had been so intensively used by elk that they had become overgrazed and denuded. Woods concluded that little, if any, deterioration had occurred because the soil was inherently very poor and shallow on most of these areas. Olson (1938) believed that early spring grazing had depleted vegetation on harsh sites on the Gros Ventre winter range. Others making up the interagency team accompanying Olson disagreed. One was Olas Murie, who later wrote that "the land simply did not produce voluminously and probably would not even with an absence of grazing" (Murie 1943, unpubl. ref.). Another member of the team believed that the condition of windswept ridges was no better or worse than 15 years earlier. Disagreement on the extent that elk had contributed to the condition of sparsely vegetated sites led to construction of exclosures and installation of line intercept transects to measure range trend.

Heavy utilization of forage on the Gros Ventre winter range by elk has been documented over the years (Olson 1938, unpubl. ref.; Baird 1958, unpubl. ref.; Buechner 1960; Smith 1961). Most investigators concluded that this heavy use had been detrimental and had contributed to range deterioration. Pedestalled plants, dead plant segments, hedged shrubs, rill erosion, and erosion pavement listed as indicators of deterioration (Ellison and others 1951) are all evident.

Heavy winter utilization of grasses and half-shrubs (Douglas rabbitbrush, winterfat, and fringed sagebrush) continues on ridges and south- and west-facing slopes near feedgrounds (plates 49-51, 55, 58). Forage on these sites is usually consumed early in the winter. Winter utilization by elk thereafter is minimal, except for localized trailing to and from feedgrounds. Pellet group counts, which included spring foraging in the vicinity of Coal Mine Draw (plate 50) from 1969 to 71 showed that southerly aspects received the lightest use of all aspects sampled. Over the 3-year period, two transects on southerly aspects averaged 23 elk-days-use/acre (57 per ha) (EDU/A) compared to 47 EDU/A (117 per ha) on the more productive swales and toe slopes and 44 EDU/A (109 per ha) on a ridge. Much of the use on the ridge reflected bedding and trailing to and from the feedground.

Winter utilization measurements of bluebunch wheatgrass on eight transects on more productive sites indicated that 86, 98, and 81 percent of the plants were grazed in 1966, 1967, and 1968, respectively, using methods described by Cole (1963). Utilization of half-shrubs was not measured, but virtually all current growth is browsed yearly.

Where elk range freely a mile or more from feedgrounds, utilization levels continue to be heavy on localized sites. However, winter utilization of forage on the Gros Ventre drainage generally has declined over the past 50 years (plates 28-30, 34-36, 38-41, 44-45, 59-60). This trend has been strongly influenced by the elk feeding program and human disturbance, particularly near the Gros Ventre road, which is traversed both by wheeled vehicles and by snow machines. An overriding factor behind reduced levels of elk use on areas one or more miles from feedgrounds is the reduction of the wintering elk herd over the past 50 years. The peak elk population during the past 50 years may have been in 1925 when 9,128 were counted on the Gros Ventre drainage. The high during the past 11 years was apparently in 1969 when 3,600 were counted. This latter figure is somewhat low, since it did not include small groups of free-ranging animals.

The photo record provides convincing evidence that southerly aspects and ridges have supported sparse plant cover for at least 75 years (plates 29, 38-39, 44-45, 49-51, 54), long before winter feeding of elk began. These photos suggest little change in plant density. Possible changes in plant composition cannot be determined, but sites were and are dominated by native perennial species.

Various procedures have been used to measure the condition and trend of the more harsh sites on the Gros Ventre winter range and those east of the National Elk Refuge. These studies are summarized and discussed in appendix IV. Information developed from these studies is inconclusive, but suggests a static condition or slight improvement in vegetation and litter.

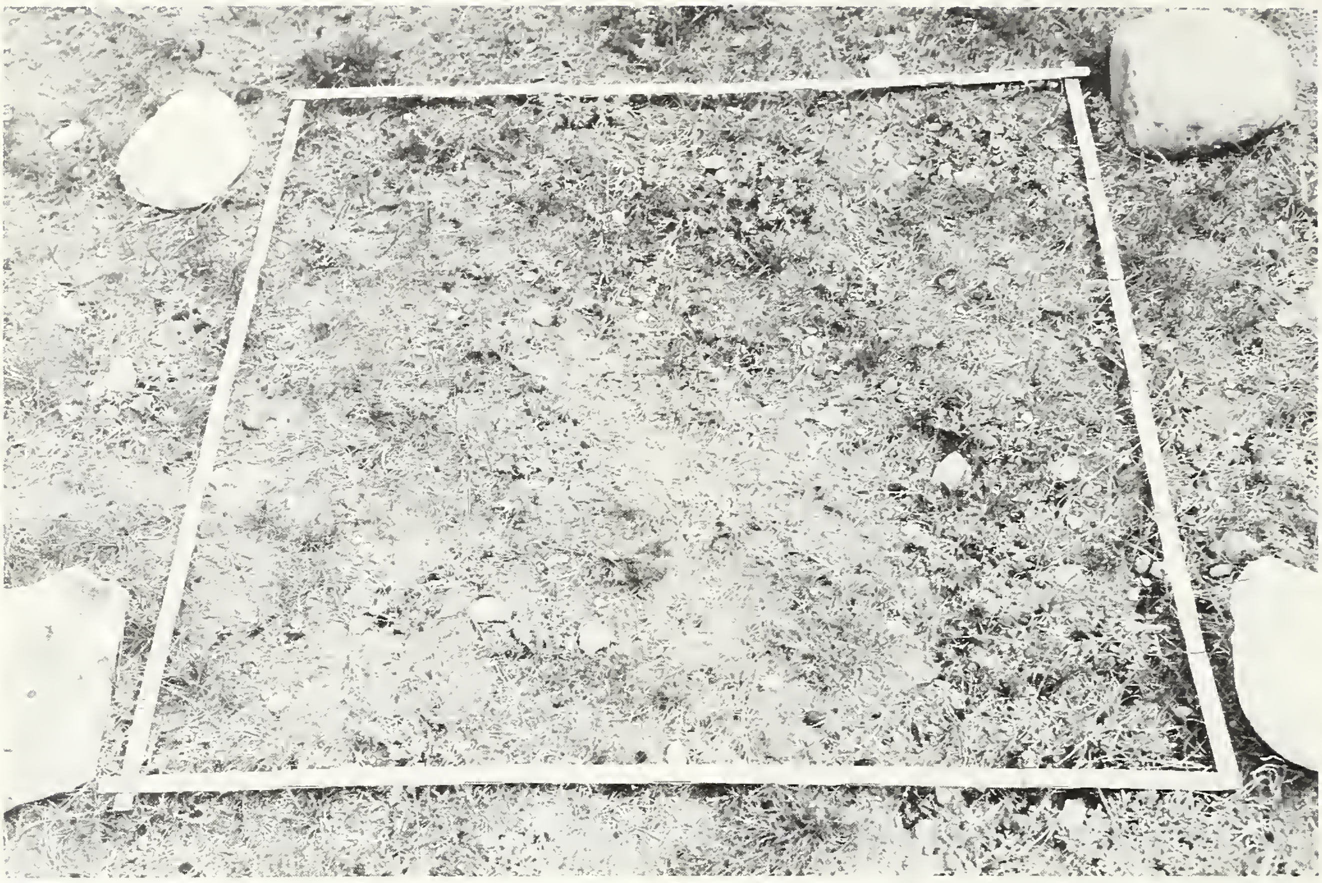
In the 360-acre (146-ha) Upper Slide Lake soil and watershed exclosure, which includes aspects typical of the Gros Ventre winter range, Olson (1961, unpubl. ref.) found that soil productivity potential was very poor to poor on 49 percent of the area and poor to fair on 17 percent. Recent soil surveys on other portions of the Gros Ventre winter range have demonstrated that sites supporting low-density plant cover are underlain by shallow, immature soils with limited potential for producing vegetation (B. Glenn 1977, personal communication). Droughty conditions prevail because of low precipitation, shallow soils, north dipping ledges, persistent westerly winds, and direct exposure to the sun. Thornton (1969, unpubl. ref.) found a dense, dry soil layer, which acts as a barrier to root penetration about 15 inches (38 cm) below the surface on some sandy clay-loam soils within the Upper Slide Lake exclosure. On sandy soils, site potential is further restricted by the inability of these soils to retain moisture (plates 45, 54). Sandy soils retain very little moisture in the root zone, whereas soils with more clay retain larger amounts of water (Taylor 1964).

The persistence of grasses on harsh sites despite habitual grazing by elk and other wild ungulates can be explained by considering grass physiology. McIlvanie (1942) found that food reserves stored in the root system of bluebunch wheatgrass are reduced to 40 percent of maximum by fall regrowth and remain at this level during the dormant spring period prior to greenup. Cured stems and leaves can be removed during dormancy without harming the plant appreciably because aerial portions have little influence on maintenance of life processes after grasses cure. The plant draws upon its root reserves to initiate spring growth; at a 4-inch (10-cm) height food reserves have been reduced to 30 percent by the regrowth process. Grazing at this growth stage does not damage the plant as long as it is allowed an opportunity for subsequent regrowth. The most critical stage for grazing is at a 7-inch (18-cm) height or at the boot stage when food reserves are down to 12 percent.

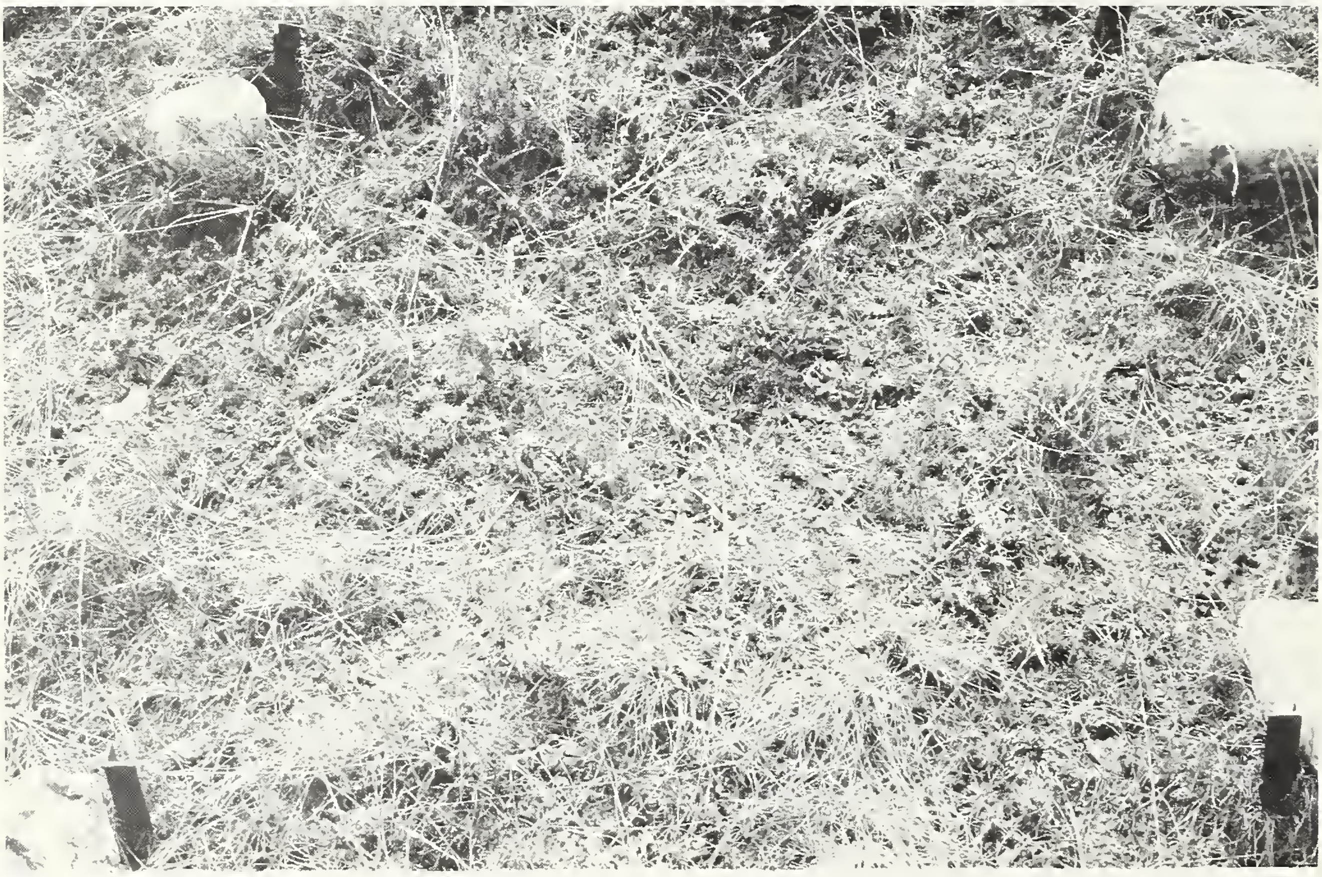
The development and storage of food reserves is essentially the same for all herbaceous species. Wasser and others (1957) pointed out that "the effects of grazing are not necessarily damaging, either to vegetation or soil. Grazing has a stimulating effect on growth under certain conditions and, as a general rule, if grazed plants are given an opportunity to make regrowth, foliage removal is not injurious."

My studies of the phenological development of herbaceous plants as related to elk use indicated that initial growth on the warmest sites occurred during the first 2 weeks of April in 1969, 1970, and 1973. New growth had not yet started on cool exposures, and snow occupied localized sites. During this period, leaf length of bluebunch wheatgrass was 1 to 2 inches (2.5-5 cm) and grazing was light. Elk were dependent on supplemental feed or cured forage picked up while grazing on open range. By the first 2 weeks in May, leaf length of bluebunch wheatgrass on warm sites was 3 to 6 inches (7.5 to 15 cm) and elk had fed on the new growth. Utilization levels vary highly at this time, depending on elk dispersal. Sites east of the National Elk Refuge and on the Gros Ventre drainage had anywhere from a few to as many as 70 percent or more plants grazed. By late May or early June when grasses on the warmest sites enter a growth stage when grazing could be harmful, elk utilization became minimal. By then the elk were well dispersed and seeking new plant growth at higher elevations or on later developing sites. This reduces use of plants on early developing sites, which have reached a critical growth stage. New growth appeared to be preferred over more advanced growth because of the higher protein content.

As with true shrubs, food storage for spring growth in half shrubs is in the roots and older branches. Elk foraging usually removes only the current growth, thereby not appreciably affecting the carbohydrate reserves. Donart and Cook (1970) found that Douglas rabbitbrush could be browsed without damage even during the critical spring period. When this species was clipped 90 percent during the period of lowest root reserves, it could restore lost reserves by the time 20 percent of the anticipated regrowth had formed. A 3x3 ft (0.91x0.91 m) quadrat immediately below exclosure No. 3 in Sec. 3, T41N., R115W., just east of the National Elk Refuge demonstrates the ability of half-shrubs to sustain themselves. Early spring photographs, taken periodically, show that all current growth of winterfat plants has been browsed off during the past 23 winters (fig. 3). The plants recover by fall and have persisted despite such heavy yearly winter browsing (fig. 4).

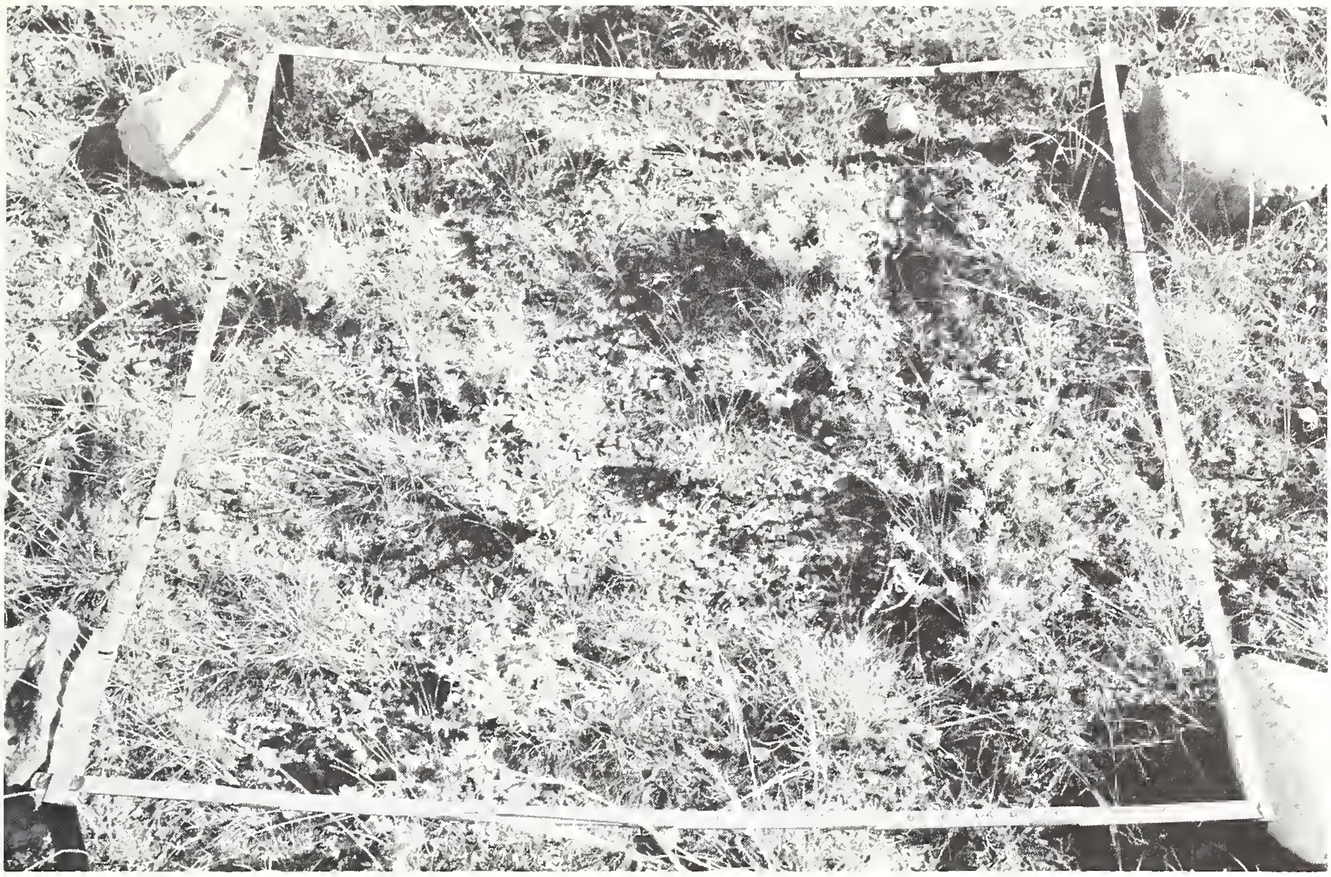


May 11, 1954

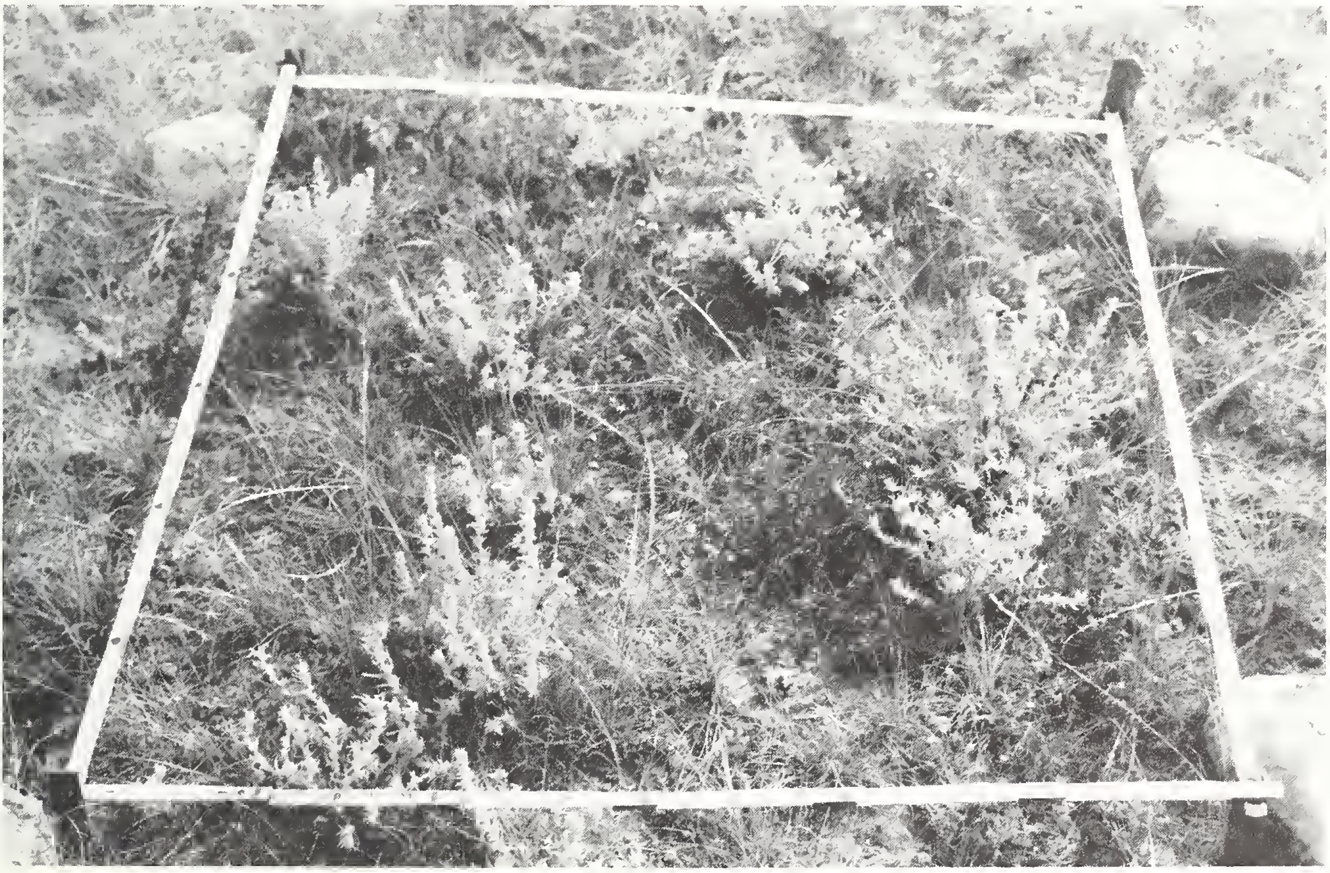


May 10, 1968

Figure 3.--A 3x3 ft (0.91x0.91 m) quadrat immediately below exclosure No. 3, showing heavy yearly browsing of winterfat. Improved ground cover in 1968 resulted from extremely good herbage production in 1967.



October 6, 1954

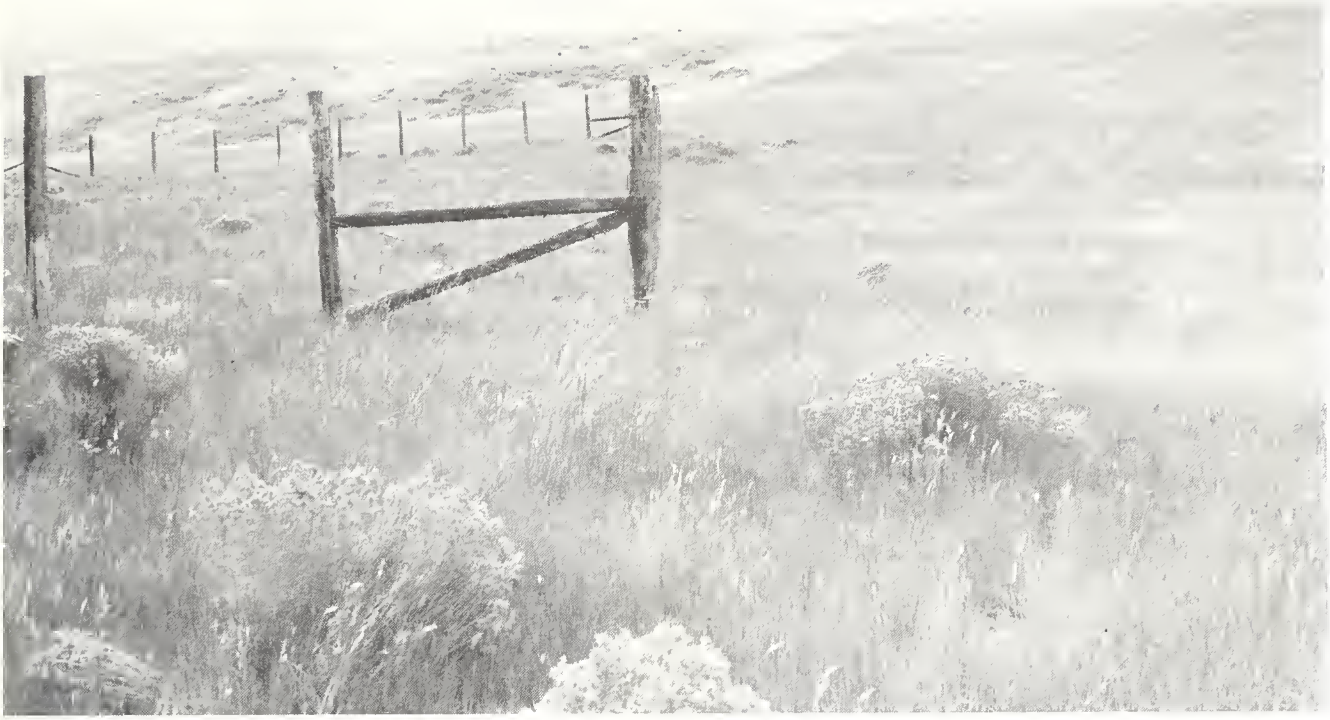


October 5, 1976

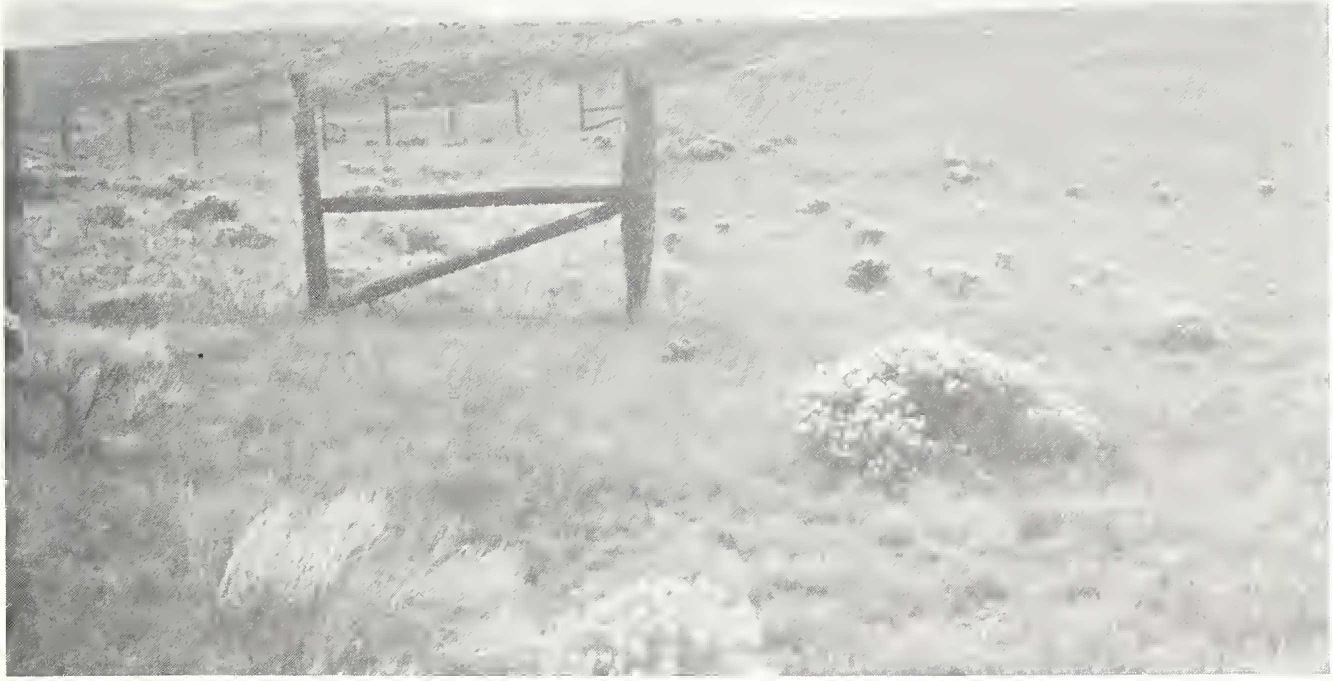
Figure 4.--*Winterfat quadrat below exclosure No. 3 at end of growing season in 1954 and 1976. Note contrast in growth. May-June precipitation was 3.63 inches (9.2 cm) in 1954 and 3.91 inches (9.9 cm) in 1976. Somewhat higher precipitation, better timing, and warmer temperatures in 1976 appear to have contributed to better growth.*

The amount and timing of precipitation is the dominant climatic factor affecting herbaceous yields on these semi-arid ranges (Blaisdell 1958). On winter ranges of Jackson Hole, good growth requires sufficient precipitation during May and June to maintain soil moisture. Temperature is also important during this period, but apparently less so than precipitation. Because spring precipitation varies greatly between years, so does annual plant growth (fig. 5).

Wasser and others (1957) pointed out that on certain big game spring ranges, trampling was far more damaging to plants than the amount of forage utilized. Although trampling can be damaging, it may also be beneficial by covering seeds and thus increasing germination and seedling establishment. Trampling may also help perpetuate grasses that regenerate from root stalks by breaking up the root system and redistributing plant segments. As noted previously, soil movement from trampling can aid bitterbrush regeneration. Variable trampling occurs on early spring ranges in the study area and is particularly heavy close to feedgrounds. Soil compaction has inhibited plant growth on habitually used trails. Trampling is by no means unique to feedgrounds, but has been an inherent characteristic of elk use on historic Jackson Hole winter ranges. Considering the decline in elk numbers, trampling intensity has probably also declined except near feedgrounds where it has intensified.



September 22, 1967



September 29, 1969

Figure 5.--*Contrasts in yearly growth of vegetation outside exclosure No. 5 east of National Elk Refuge. May-June precipitation was 6.16 inches (15.6 cm) in 1967 and 1.43 inches (3.6 cm) in 1969. The area had been seeded in 1953.*

Exclosures permit assessment of growth potential of half-shrubs and other low-growing herbaceous vegetation on winter ranges. The area outside exclosure No. 3, constructed in 1952, on a west- and south-facing slope east of the National Elk Refuge has received heavy utilization because it is adjacent to the Refuge where between 7,000 and 9,000 elk winter. Close inspection of the better producing west slope inside the exclosure shows that half-shrubs, Hoods phlox, pussytoes, and other less common species have put on accumulative growth compared to plants outside the exclosure. Dead material has accumulated at the base of grasses, and litter buildup has improved ground cover. Although evident, the magnitude of these changes during the past 24 years has not been striking (fig. 6).

On the west slope outside the exclosure, the crowns of half-shrubs are largely comprised of annual growth. The growth form of Hoods phlox and pussytoes has been suppressed by yearly trampling. Elk foraging has prevented plant material from accumulating as litter.

After 26 years, the magnitude of change on a south slope within the exclosure is less because of lower site potential. Grasses have increased in basal area, accumulative growth is evident on half-shrubs, interspaces between plants have not filled in appreciably, and litter buildup is negligible. Plant cover on the south slope outside the exclosure has declined due to heavy trampling that has been aggravated because the exclosure fence restricts movement.

Differences between vegetation within and outside exclosures should be viewed in proper perspective. Having been artificially induced, conditions inside exclosures do not represent pre-settlement conditions. Elk have used palatable plants on topoedaphic sites for centuries, and have prevented accumulative growth on these sites. Plants are currently composed primarily of current growth

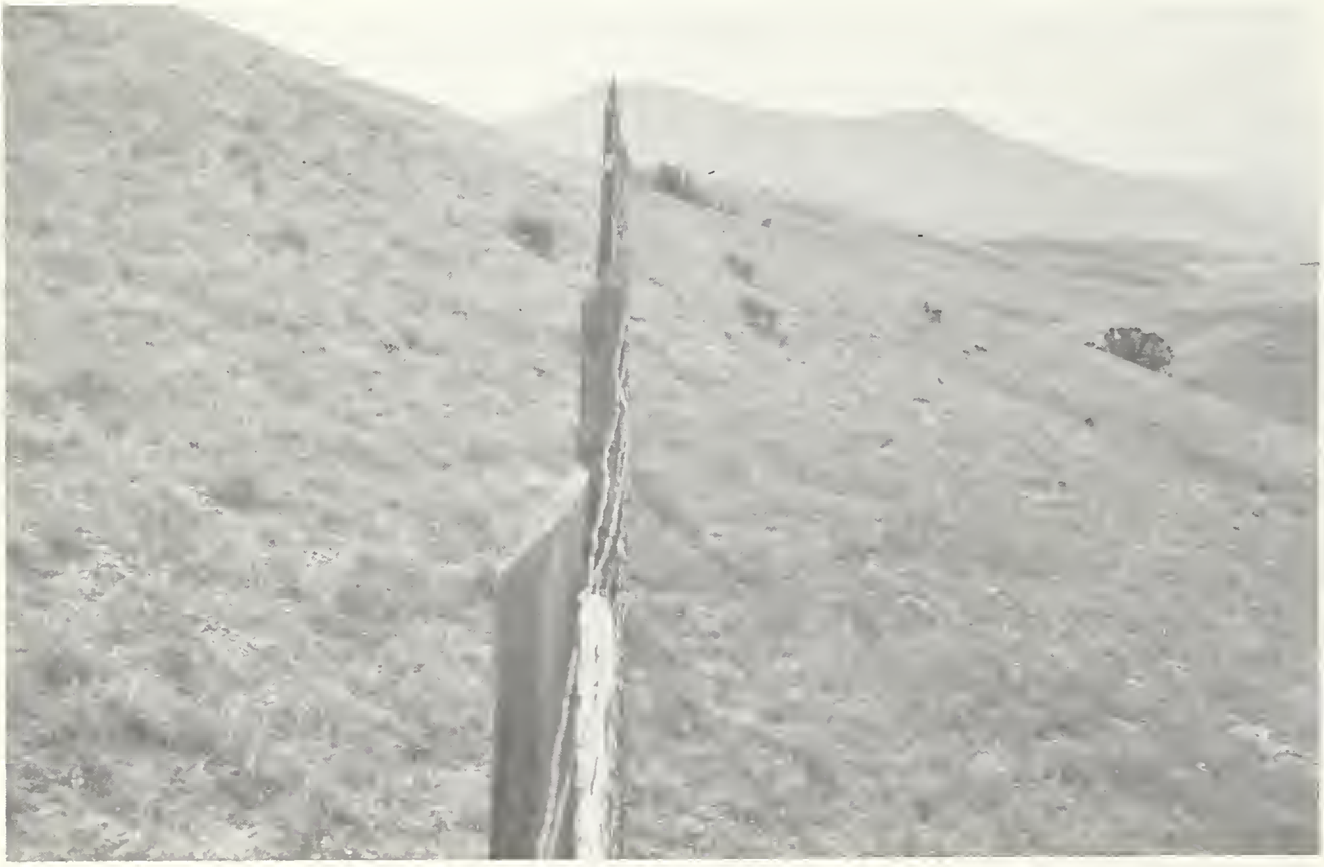


Figure 6.--Exclosure No. 3 - October 5, 1976. Protected plants are on the left, grazed plants on the right.

and I believe this has been the norm. Conditions immediately outside exclosures are also somewhat artificial, because fences restrict free animal movement and concentrate trailing.

Considering all the evidence, it is apparent that vegetation on south- and west-facing slopes on elk winter range has not been greatly altered since settlement. After all, these sites have limited potential to produce vegetation because of several interacting factors: slope; exposure; shallow, sometimes coarse-textured soils; less snow cover; and persistent westerly winds that result in xeric conditions. Palatable species have persisted despite extreme grazing by elk. However, the utilization of cured grasses and half-shrubs has been during winter when stored food reserves are not affected. Utilization of new grass growth in the spring is prior to the critical growth stage thereby allowing grasses to subsequently restore food reserves and build up vigor.

Tall Forb Vegetation on Summer Ranges

Bailey (1915, unpubl. ref.) concluded that summer range in Jackson Hole was abundant and in good condition. Graves and Nelson (1919) also reported that the summer range was plentiful and constituted no serious problem. More recently, concern has developed over the effects of elk use on summer range—notably Big Game Ridge in the Teton Wilderness (Beetle 1952, unpubl. ref.). Croft and Ellison (1960) concluded that elk were responsible for deterioration of the grazable vegetation and watershed on Big Game Ridge, although they recommended further study. Gruell (1973) concluded that elk had not been responsible for deterioration of either the grazable vegetation or watershed on Big Game Ridge.

The photo record does not demonstrate any appreciable change on Big Game Ridge between 1915 and 1969 (plates 17-22). Snowbank sites apparently support more plants than 50 years ago, which is consistent with trends on other widely separated, high-elevation summer ranges (plates 14-16, 26-27, 83, 85) where plant density has remained constant or improved in the past 75 to 100 years.

Plant densities on summer ranges reflect site potentials. Well developed, clay-loam soils support good plant cover and a variety of tall forbs and grasses. Vegetal production is low on snowbank sites, exposed ridges, and southerly aspects where soils are commonly shallow or rocky. On these sites, deficient soil moisture and restricted rooting opportunity are the principal inhibitors of plant growth. Snowbank sites have a particularly low potential for plant growth because of short growing season and harsh growing conditions. Thilenius (1975) points out that alpine soils under late-lying snowbanks are poorly developed and often low in humus. Their low water-holding capacity accentuates drought-stress.

Low density vegetation on harsh sites is often comprised of annuals. Their perpetuation is assured by recurrent churning of the soil surface by pocket gophers (Gruell 1973). Early narratives suggest high pocket gopher populations in pre-settlement times. Their presence reflects ideal habitat in the form of a large volume of herbaceous vegetation, rather than habitat deterioration.

Forage utilization on Big Game Ridge was probably greater prior to settlement when elk numbers were high. In recent years utilization has not been excessive (Gruell 1973), particularly considering how elk feed on the vegetation. Of plants utilized on representative sites on Big Game Ridge, less than half of the growth was removed. Annual variations in elk distribution patterns increase the probability that some plants grazed one year will not be utilized the following year. In effect, a deferred rotation grazing system has evolved. Sites with low plant density consistently received the lightest utilization because they were less inviting to elk.

Reasons for the apparent increase in plant density on harsh, high-elevation sites suggested by photos are presently unknown, but the following factors may be involved. Heavier utilization of preferred flowerheads and succulent terminal stems of herbs by the large elk population in earlier years may have given the landscape the appearance of having a more sparse plant cover. Fluctuations in pocket gopher densities could likewise influence plant cover both by utilization and soil disturbance. The coincidence of high pocket gopher populations and a poor year for plant growth could temporarily reduce plant cover (plate 22) and could account for an apparent subsequent increase in plant densities on some sites.

However, not all the change can be explained by a decline in elk utilization or variation in pocket gopher activity. The increase in plant density on snowbank sites and other sites that supported low-density vegetation before the turn of the century suggests that climatic change may be involved, most likely a warming trend (Bray 1971; Mitchell 1970). Such a trend since the mid-1800's and especially since 1920 is evidenced by the retreat of local glaciers. Warming would have melted snowbanks earlier, extended the growing season, and improved opportunity for plant establishment and growth. Long-lived species which regenerate vegetatively, such as longleaf arnica, would also have been favored through proliferation of new stems from the spreading root system.

Watersheds

Watershed conditions in the study area differ according to the geology. Those in the northeastern part are relatively stable since soils are derived from rhyolite flows, breccia, and conglomerates. Much of the material transported by these streams is as bedload. Most of the other watersheds are underlain by soft sedimentary formations and the predominantely fine erosional materials are largely transported as suspended sediment. Some streams in the Gros Ventre range carry mostly dissolved material because they flow through hard limestone and dolomite bedrock. Included are Flat Creek, Crystal Creek, and Granite Creek which run practically clear, for the most part, during high water. These streams are the exception. All others run muddy and carry either suspended sediments, bedloads, or both.

Some historical perspective on the watershed condition is provided in early narratives covering the Big Game Ridge locality. Barlow and Heap (1872) reported that the upper Snake River, which drains Big Game Ridge, was subject to severe freshets. Bradley (1873) described the wide variability of runoff and "great freshets" by noting the condition of the broad gravelly bottom of the Snake River. According to him, these conditions resulted from rapid melting of the snow on treeless areas at higher elevations where many localities were "badly washed." Tributary drainages which head on Big Game Ridge continue to carry high volumes of water and heavy loads of suspended sediment during peak runoff or after cloudbursts. Sheet and rill erosion is common, especially on steep slopes and below late-melting snowbanks. Thilenius (1975) found that the normal process of cryopedogenesis (intensive frost action) and natural erosion on alpine ranges can cause many of the features listed in the Forest Service Range Environmental Analysis Handbook as symptoms of retrogressing soil stability. This applies to many alpine localities on Big Game Ridge, Two Ocean Plateau, and the Buffalo Plateau.

Watershed conditions on the gentle-to-moderate slopes of Big Game Ridge have not changed appreciably since 1915 (plates 17-19). Little change also is indicated on a similar area near Wildcat Peak (plate 15). Measurements in 1976 of 10 erosion pins placed in 1969 on Big Game Ridge showed erosion rates to vary with the percentage of slope. Soil loss around 3 pins on a snowbank site of approximately 35 percent slope varied between 0.25 inch and 1.62 inches; the loss around 4 pins on gentle slopes was 0.25 to 0.38 inch. One pin was covered by pocket gopher casts and 2 others were presumably covered and lost. These data show that sheet and rill erosion is carrying soil from the steeper slopes where plant cover is sparse, but I believe that the rate is not greater than presettlement times. The rate of erosion on gentle slopes is quite slow, with the surface of the soil fluctuating more from pocket gopher activity than erosion. Gullies on the upper slopes of Big Game Ridge formed during the closing stages of Pinedale glaciation some 9,000 years ago (Richmond and Pierce 1971). A. F. Galbraith, hydrologist, Bridger-Teton National Forest (1976, personal communication) pointed out that these gullies could not have developed in historic times because surface area of the watershed above is insufficient to generate adequate water velocity for accelerated cutting.

The photo record also indicates that erosion on sites of low-density plant cover on the Gros Ventre winter range has not changed appreciably since settlement (plates 36, 38-41, 45-46, 49-50). Gully patterns and depths appear relatively the same after 50 to 75 years. Soils are moderately to highly erosive, with sheet and rill erosion common in localized areas after cloudbursts or rapid snow melt. Generally, sediments moved by sheet or rill erosion are deposited in vegetation before reaching the Gros Ventre River. Sediments, however, do reach the Gros Ventre River where the source area is immediately adjacent (plate 38). The high loads of suspended sediment carried by the Gros Ventre River have their source in the upper reaches of the river and its tributaries, which flow through unstable material. Bailey (1971) recognized mass wasting as one of the most effective erosional processes in the area. High relief, steep slopes, deformed weak bedrock, excessive slope water content, earthquake shocks, and slump undercutting all contribute to high sediment loads (plate 49). Evidence that high volumes of suspended sediments were natural is found in early narratives. Ingersoll (1883), while with the 1877 Hayden Survey, noted that the upper Hoback River ran high and muddy following warm weather, which melted upper elevation snowpacks.

Streams and rivers flowing through broad flood plains of soft sedimentary material are constantly changing (plates 8-11, 23, 50, 58, 61-62, 74). In these areas, great quantities of material are redeposited after being carried in suspension or cut from streambanks. Accumulation of this material diverts flows to new channels where material in turn is eroded away. As one would suspect, streams that carry heavy bedloads are also highly changeable (plates 1-4). The upper watershed of Pass Creek includes extensive areas of bedrock or shallow soil, with low-density plant cover. Rapid melt of snowpack or runoff from cloudbursts results in high volumes of water that carry the conglomerate bedload for some distance. Comparable situations occur throughout the study area. One is Pacific Creek below the outlet of Gravel Creek where the primary source for conglomerate erosional material is Gravel Mountain to the east. Great quantities of this material have been transported down a tributary to Pacific Creek over the centuries.

No appreciable channel changes have occurred where flows are restricted by terrain features (plates 37, 40-41, 66-67, 70, 75). Streambeds in these localities have usually reached bedrock, and flows are confined within narrow limits.

Overland flows have varied over the centuries, depending upon the successional stage of the vegetation. Removing trees from a watershed temporarily increases the amount of water flowing from it (Hibbert 1967). Prior to settlement this was accomplished by insects, disease, and wildfire in the Jackson Hole region. Overland flows today are probably reduced over presettlement times when wildfire kept much of the coniferous forest in seral stages. Young forests draw less upon ground water thereby leaving more water available to shrubs and herbaceous plants and as free water for aquifers, springs, and streams. The great biomass of today's mature and overmature forests draws heavily on ground water and reduces free-flowing water, particularly during the summer when transpiration is highest.

From the photographic evidence and geologic information, watersheds in the Jackson Hole region appear to be functioning naturally, with erosion rates no greater than 100 years ago. Most of the landscape is protected by soil-stabilizing vegetation. Surface erosion is mainly confined to sparsely vegetated steep slopes on both summer and winter range. The heavy loads of suspended sediments carried by most streams during peak runoff or following cloudbursts originate in the upper watersheds. High relief, steep slopes, deformed weak bedrock, excessive slope-water content, earthquake shocks, and slump undercutting all contribute to high sediment loads. Some workers have believed that the rate of erosion has accelerated in some areas since settlement because of increased elk use attributable to man's activities (Beetle 1962). The evidence does not support this interpretation.

Human Occupancy

Development on the Teton Division of the Bridger-Teton National Forest is largely confined to private inholdings of about 28,500 acres (11 538 ha) (2 percent of the area). Except for a few isolated tracts, these lands are along the Buffalo Fork River, Gros Ventre River, Snake River and Hoback River, and were homesteaded between 1893 and 1920. Most are still used for ranching, particularly in the Hoback Basin.

With human population increases, these lands are being developed for housing and recreation. In recent years development has increased dramatically as more people discover Jackson Hole. Although the area being developed is small when compared to the total acreage of National Forest lands, this development has influenced wildlife. Much of this land has been important as winter range for large ungulates because of its valley location. Current trends indicate that development will continue to the detriment of wildlife, particularly to large ungulates.

MANAGEMENT IMPLICATIONS

This study indicates little change in vegetation on sites of low potential. Because of low potential, there is little opportunity to improve these sites. There has been much change where potential for plant growth is favorable. Various biotic and abiotic agents have influenced this change, but it appears that the primary influence has been a reduction in acres burned. Prior to settlement of Jackson Hole, wildfires are thought to have stimulated renewal of vegetative cover by creating a mosaic of variable aged vegetation. Seral herbaceous plants, deciduous shrubs, and deciduous trees were well represented. The reduction in acres burned has allowed vegetation to advance successionally, and fuels to build up greatly over wide areas. Much early seral vegetation has either died or become senescent, resulting in reductions in carrying capacity and heavy utilization of remaining palatable species by wild ungulates. Changes in vegetation have had far reaching influences on wildlife and other fire-dependent systems.

The influences of burning on fire-dependent western and northern conifer forests have been enumerated by Wright and Heinselman (1973) and summarized as follows by Mutch (1976): Fire influences the physical-chemical environment; regulates dry-matter accumulation; controls plant species and communities; determines wildlife habitat patterns and populations; controls forest insects, parasites, fungi, etc.; and controls major ecosystems, processes, and characteristics (nutrient cycles, energy flow, succession, diversity, productivity, and stability).

Because fire is an integral part of the ecosystem, it is being integrated into land management planning. Management objectives will vary with differences in land capability and management commitment. The overall objective of fire management outlined in the new Forest Service Fire Management Policy is to provide fire protection and use programs that are responsive to land and resource management goals and objectives. A key element of this direction is to provide for prescribed fire, using either planned or unplanned ignitions to maintain and enhance production of National Forest resources.

A primary management objective in the Teton Wilderness is to allow natural systems to function. This management objective was furthered by implementation of a natural fire management plan in 1976 (Reese and others 1976). A comparable fire management plan is also being prepared for the Bridger Wilderness in the Wind River Range. The Teton Wilderness fire management plan allows lightning fires to play a more natural role. Fires in nine fire management units will be closely monitored and allowed to burn naturally, or be partially contained, totally contained, or suppressed depending upon predetermined prescriptions. Burning along the northern boundary will be closely coordinated with Yellowstone National Park which operates under a similar fire management plan.

Of the 3,423,412 acres (1 385 997 ha) comprising the Bridger-Teton National Forest, 2,273,933 acres (920 621 ha) are outside designated Wilderness and other special areas. The latter acreage includes 710,881 acres (287 806 ha) (33 percent) where trees are not the primary vegetation. The use of prescribed fire on these lands has been considered in the land management planning process (see Spread Creek-North Gros Ventre Land Use Plan). As of 1977, two prescribed burns in late summer, one in the fall, and four in spring, totaling approximately 3,100 acres (1 255 ha) have been carried out in this planning unit and on adjacent lands. All of these burns have been on sagebrush-grass livestock allotments which also encompass elk and moose winter range. With few exceptions, future opportunities for prescribed burning will also be on dual use ranges. Close cooperation, coordination, and commitment by the Forest Service, Wyoming Game and Fish Department, and livestock permittees will be required. All parties acknowledge the potential benefits of burning on the Gros Ventre River drainage, and burning plans are being developed to meet management objectives and assure continuity of effort. These plans should serve as forerunners of others on the Forest.

Lands outside designated Wilderness areas also include 479,808 acres (194 254 ha) (22 percent) in forest tree cover types not allocated for commercial harvest. Much of this land has a high potential for supporting wildlife. A long fire-free interval has caused a decline in plant diversity, a reduction in carrying capacity for many wildlife species, and an altering of fuels. Years without fire's influence have locked up important nutrients and have postponed the inevitable release of energy by wildfire (Roe and others 1971). The likelihood of large, high-intensity fires is considerable in some areas because of great, contiguous fuel accumulations. Fuel reduction by prescribed fire can be achieved with adequate funding, intensive planning, and total commitment. Prescribed fire could also be complemented by zoning and preplanning to allow wildfires to burn under prescribed conditions in conformance with the new fire management policy. Rather than suppressing all fires, some could be allowed to burn under prescription, thereby providing multiple benefits.

Many wildlife habitat improvement opportunities also exist on commercial forest lands, which make up 45 percent of the Forest outside of designated Wilderness areas. Here, fires are suppressed to protect forest resources and provide a continuing supply of harvestable timber. Since 1956, approximately 40,000 acres (16 194 ha) (9 percent of the standard and special component of 4 percent of the total commercial forest including the marginal component) has been cut. Most of the harvest has come from the standard component in more accessible stands, including some heavy tree removals from restricted areas. A new timber management plan in preparation would reduce the annual allowable programmed harvest, thereby spreading out the harvest and assuring a wide range of successional stages in future years.

Harvests over the past 20 years have improved successional diversity and helped reduce the probability of large high-intensity fires. Future opportunities for improvement of wildlife habitat by timber harvests are many, especially where aspen are a component of the vegetation, but improvement will be contingent upon coordinated planning and proper execution of sales. In some areas, failure to close timber access roads has resulted in heavy hunter harvest and disturbance of wildlife. If wildlife is to benefit from logging, public use must be restricted on roads traversing areas of high wildlife value.

To simultaneously support large numbers of species and individuals, all stages of plant development must be represented. Maintaining a variety of wildlife species requires the kind of forest management that maintains plant and habitat diversity (Noble 1973). Benefits will vary depending on the wildlife species and successional stage. Many wildlife species increase during early plant succession while others are displaced or eliminated until latter succession (Komarek 1966).

Early seral vegetation favors most large herbivores by enlarging the food base and improving the quality of the forage. In earlier years, elk winter range in the study area was enhanced by widespread increases in production of perennial grasses, forbs, and deciduous shrubs and trees following fires. Antelope and bighorn sheep summer ranges were likewise benefited. Fires on both high and low elevation bighorn sheep winter ranges opened conifer stands thus increasing forage production and availability by allowing winds to blow away snow.

Early successional plants also favor many small herbivores. Snowshoe hare population explosions are limited to early succession when new forest reproduction covers large acreages (Grange 1965). Burning to benefit upland species in Wisconsin also benefited muskrats (*Ondatra zibethicus*), rabbits, and rodents (Vogl 1967). Considering these results it is probable that the yellow-bellied marmot (*Marmota flaviventris*), white-tailed jackrabbit, and other small herbivores that prefer open habitats in the study area would likewise benefit from fire.

The beaver is an outstanding example of a herbivore adapted to seral vegetation. I have observed numerous instances were loss of aspen for food and dam-building material due to successional changes caused sharp population declines or abandonment of the area. Current beaver populations in western Wyoming largely depend upon willow, which is structurally inferior as dam-building material and not as nutritious as aspen. Huey (1956) found that beaver on an aspen diet produced litters double those of beaver on a willow diet.

Carnivores including the wolf (*Canis lupus*), coyote (*Canis latrans*), red fox (*Vulpes fulva*), mountain lion (*Felis concolor*), lynx (*Lynx canadensis*), bobcat (*Lynx rufus*), grizzly bear (*Ursus arctos*), black bear (*Ursus americana*), longtail weasel (*Mustela frenata*), mink (*Mustela vison*), wolverine (*Gulo luscus*), badger (*Taxidea taxus*), and striped skunk (*Mephitis mephitis*) depend upon herbivores for food. Successional changes favoring herbivores also favor carnivores, but timing depends on the relative availability of herbivores. Prescribed burning in Wisconsin favored the Wisconsin badger shortly after burning (Vogl 1967). Edwards (1956) concluded that an intense wildfire in British Columbia covering 200 square miles created new habitat for wolverine, wolves, and grizzly bear, and allowed mountain lion to become common and coyotes to flourish 30 years after burning.

Different bird species inhabit different types and stages of forest succession. In general, birds use more than one seral stage, almost none breed in all stages, and a few are restricted to only the old growth or climax vegetation (Wight 1974). In Yellowstone Park, Taylor (1969) found more bird species in open habitat that had burned 9 to 27 years previously than in closed conifer forest that had burned in 1910 and 1856. Mixed pine-hardwood forests kept open by frequent ground fires in Mexico support a larger number of species than adjacent closed forests in Arizona, which have been protected from fire (Marshall 1963). Gullion (1970) reported that the greatest ruffed grouse (*Bonasa umbellus*) populations in northern Minnesota occurred 2 to 4 and 10 to 12 years after peak fire seasons when aspen was in early succession. On Vancouver Island, British Columbia, densities of breeding blue grouse (*Dendragapus obscurus*) are low in mature forests, but populations usually increase rapidly following logging or burning (Bendell and Elliott 1966).

Advanced stages of succession or old-growth coniferous forest are clearly favored by certain wildlife species. Thomas and others (1975) pointed out the importance of old-growth ponderosa pine, Douglas-fir, and spruce-hemlock forests for cavity nesting birds. Pine marten are closely tied to old-growth forests, although fire and good timber harvest practices can maintain the diversity beneficial to pine marten and other wildlife (Koehler and others 1975).

The great increase in moose numbers throughout the study area since 1900 may reflect natural expansion into suitable but previously unoccupied habitat. However, moose appear to have been favored by successional changes that have occurred since settlement.

Numbers were low around the turn of the century when much habitat was in early succession. Moose populations did not increase significantly until more advanced stages of succession were reached 60 years or more after large wildfires. Increases apparently resulted from improved availability of winter forage, especially subalpine fir which increased enormously over wide areas with reduced fire periodicity. Subalpine fir has been a staple winter food—oftentimes the only forage available in late winter when snow depths of 3 to 6 feet (0.91 to 1.83 meters) largely covers deciduous species at elevations between 6,500 and 9,000 feet (1 982 and 2 744 meters). This primary food source along with taller deciduous species apparently allowed moose to overwinter in many localities where sufficient food was not available in earlier succession. Studies in Alaska and Canada show that moose increase in response to earlier successional stages (Spencer and Hakala 1964; Cowen 1950, and others). Differences in findings may be tied to differences in successional relationships. Deciduous shrubs and trees in northern latitudes are usually well represented, re-establish rapidly after fire, and have the potential of growing tall. Much of this vegetation remains above the snow level during the winter. Succession is slower in Jackson Hole and there are fewer tall shrubs and trees. Deep snow restricts availability of this forage, especially in early succession. Habitually heavy utilization over several decades and closing of the forest canopy has resulted in a significant reduction in the winter carrying capacity for moose. Rejuvenation of these winter ranges can be accomplished by fire and logging, but benefits for moose will probably not be realized for many decades.

Mule deer apparently have also benefited from advancing succession. Settlers reported that they were scarce about 1900 (Bridger-Teton National Forest files), but numbers have been relatively high since the 1950's. This change appears to have been materially influenced by the increased availability of deciduous shrubs and mountain big sagebrush, a staple food of wintering deer in Jackson Hole and other areas in the West (Leach 1956; Dietz and others 1962). Future wildfires on sagebrush-dominated deer winter range in Jackson Hole will set succession back and result in a temporary reduction in the winter carrying capacity. It appears advisable that until the carrying capacity on sagebrush-dominated winter deer ranges materially declines, prescribed burning should be held to a minimum.

Cavity-nesting birds, including the tree swallow (*Iridoprocne bicolor*), mountain bluebird (*Sialia currucoides*), black-capped chickadee (*Parus atricapillus*), house wren (*Troglodytes aedon*), yellow-bellied sapsucker (*Sphyrapicus varius*) and others have benefited from successional advances by having more opportunity for nesting in mature and decadent aspen stands. Opportunities for nesting in aspen are minimal during early succession because of the predominance of young trees too small to support cavities. The widespread increase in mountain big sagebrush has been favorable to the Brewer's sparrow (*Spizella breweri*), which prefers sagebrush for nesting. In a Wyoming study, no evidence of nesting could be found after a stand of sagebrush was sprayed with the herbicide 2,4-D (Schroeder and Sturges 1975).

From the foregoing, it is evident that wildlife habitat preferences vary widely. Despite the variability in preferences, many animals are adapted to early successional postfire stages where food and cover are more plentiful. It is clear that wildlife in Jackson Hole, as elsewhere, evolved in an environment that was subject to continuous change. Changes were largely brought about by recurrent wildfires. Because fire is a natural phenomenon that initiates many beneficial processes and because it should not be eliminated from the system, fire must be integrated along with timber management into long-term land management plans. There is no infinite stability, only dynamic change. Wildlife habitat management, whether it is for big game, small game, or nongame, must become vegetation management in order to be successful over the long run.

The combined evidence indicates that wildlife, timber, and fire management efforts in the future should be consistent with the National Forest Planning Act of 1976 by providing for plant diversity and maintenance of more natural levels of fuel loading. These objectives must be tempered by management constraints in particular land units and coordinated with various uses and activities. Management techniques will vary with differences in land capability and management commitment. The opportunities are there. How much is achieved will depend on commitment.

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APPENDIX I

Definitions[1]

accelerated erosion - Erosion caused by the influence of man.

advanced or late succession - A plant community that has replaced earlier communities and within the writer's judgment, 100 years or more since a major disturbance.

bedload - Materials larger than sand carried downstream by peak flows.

biomass - The total weight of living plant material.

biotic community - Plants and animals.

clearcutting - Harvest of conifers by cutting all trees on a given site.

climax - The highest ecological development of a plant community capable of perpetuation under the prevailing climatic and edaphic conditions.

clones - Individual stands derived by asexual reproduction from a single parent.

deciduous vegetation - Trees and shrubs which shed leaves during dormancy. Most species can regenerate from root crowns or root stalks.

early succession - Refers to plant community recently established (50 years or less) following a major disturbance, usually a fire, also flood or wind.

endemic - Native to the area.

forbs - Herbaceous plants other than grasses, sedges, and rushes.

freshet - Runoff from rapid snow melt.

geologic erosion - Perennial plants with a woody base whose annually produced stems die back each year.

herbaceous plants - Seed producing annuals, biennials, or perennials that do not develop persistent woody tissue, but die down at the end of a growing season.

hedged condition - Shrubs whose growth form has been suppressed by persistent ungulate browsing.

marginal component - The component of the regulated, commercial forest land not qualifying as standard or special components primarily because of excessive development cost, low product values, or resource protection constraints.

microclimate - Climatic condition of a small area resulting from the modification of the general climatic conditions by local differences in elevation, exposure, or vegetal change.

plant community - An aggregation of plants within a specified area.

plant succession - The replacement of one plant community by another over time.

rill erosion - Erosion process in which numerous small channels only several inches deep are formed.

seral - Plant communities that are replaced with successional changes.

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[1] Source documents - Resource Conservation Glossary, Soil Conservation Society of America, and Dictionary of Geological Terms, American Geological Institute.

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sheet erosion - The removal of a fairly uniform layer of soil from the land surface by runoff water.

site potential - The inherent ability of a site to produce vegetation.

special component - The component of the regulated commercial forest land area that is recognized in the land use plan as needing specially designed treatment of the timber resource to achieve landscape or other key resource objectives.

standard component - The component of the regulated (FSM 2415.3) commercial forest land area on which crops of industrial wood can be grown and harvested with adequate protection of the forest resources.

topoedaphic - Combination of slope, aspect, and soil characteristics that influence vegetal growth.

wild ungulates - Hoofed big game animals including elk, moose, mule deer, bighorn sheep, and antelope.

xeric - Sites having limited available moisture.

APPENDIX II

Condition and Trend Studies

Table 1 lists winter range condition and trend studies on the Gros Ventre drainage and on the Forest east of the National Elk Refuge. Initial studies consisted of individual species plots and chart quadrats. The individual species plots, either a square rod or 10 x 10 feet (3.05 m x 3.05 m), were used to study changes in vegetative cover. The chart quadrats mapped all vegetation within the quadrat. Both techniques proved unreliable for application by field men and no usable information developed.

Studies at the 0.75 acre (0.3 ha) 1939 exclosure (dismantled in 1960) included 5 camera stations and 16 line intercept transects (Canfield 1942). Photos taken at these stations have been lost. Between 1942 and 1962, vegetation on the 8 transects inside the exclosure showed an increase from 8 to 11 percent; bare ground decreased from 92 to 89 percent. Measurements in 1952 of the 8 outside transects showed no change. Measurements in 1962 of the 2 transects (only ones remaining outside after construction of 1960 exclosure) also suggested no change (Thornton 1969, unpubl. ref.).

Two photos taken at the 30 ft (9.1 m) square experimental reseeding exclosure in 1939 were retaken in 1968 by I. R. Thornton. These photos show establishment of crested wheatgrass both inside and outside the exclosure. The outside had been grazed from 1939-1960. Since 1960 it has been under protection.

Parker 3-step transects (Parker 1950) on the Teton Forest were analyzed for accuracy in 1968 during an inter-regional evaluation study under the direction of the Rocky Mountain Forest and Range Experiment Station. Included were 31 transects (29 on low productivity sites) on the Gros Ventre and East Refuge winter ranges. Because of errors that could not be corrected during the analysis, only seven of these transects were acceptable for measuring trend (Genz 1968, unpubl. ref.). However, a few of the rejected transects could later be used for determining trend by making some corrections or remeasuring the transect. Others were usable for determining changes in species composition, while many had a reasonably good photo record. All seven of the transects usable for determining trend were on the Forest east of the National Elk Refuge. Two were on a productive bottom land and are not discussed here. The other five on less productive sites were installed in 1952 and remeasured in 1960 and 1967. Three were inside exclosure 3 and showed no significant change in plant or forage cover indexes between 1952 and 1967. In 1967, the desirable plant index showed an improvement over 1960, but was below 1952 despite protection. Ground cover indexes and bare soil ratings improved significantly between 1952 and 1967. After 15 years, the two transects outside of exclosure 3 showed no significant change in either plant cover or forage cover indexes. The desirable plant index showed a downward trend, while both ground cover indexes and bare soil ratings showed significant improvement.

Comparison of existing conditions within the Upper Slide Lake exclosure with those depicted in 43 photos taken in 1960, 1961, and 1962 shows accumulative growth on shrubs and improvement in ground cover on the more productive sites. Little change is evident on less-productive sites (original photos on file at Gros Ventre Ranger District office).

Nineteen 0.96 ft^2 (0.29 m^2) circular plot transects on ridges near the Alkali feedground were remeasured in 1962 and 1965 by estimating the percent bare ground, soil, rock, pavement, and vegetation and litter within each plot. Estimates suggested an increase in vegetation and litter from 37 to 46 percent. This was apparently due to the fertilizing effect and accumulation of elk droppings encouraged by supplemental feeding. An increase in litter from pellets and stimulation of plant growth was evident near the transects.

Measurements on four of five 0.96 ft^2 (0.29 m^2) circular plot transects inside the 360-acre Upper Slide Lake exclosure showed a decrease in vegetation and litter of 6 percent after 3 years on one transect and an increase of 2 percent after 6 years on three transects.

Thornton (1969, unpubl. ref.) evaluated site potentials and condition and trend within the Upper Slide Lake soil and watershed exclosure, including seeding and fertilization trials, shrub plantings, and contour trenching. He determined that "moisture supplies in the mineral mantle of the south and southwest slopes may not be replenished to maximum capacity during the spring period. This imposes a direct limiting effect on vegetation production regardless of the productivity potential." The data suggested that the sparse ground cover was an inherent characteristic of the site. Thornton believed that elimination of all grazing on south, southwest, and west slopes would probably not result in establishment of more dense ground cover. After 8 years protection, no change was detected on sites with very poor to fair productivity potential, which included much of the area. Improved plant vigor and buildup of litter was found on more productive sites that had good soil moisture. Excepting localized sites on contour trenches, browse, grass and forb plantings, and seedings failed. Contour trenching was determined to be impractical, uneconomical, and unsuccessful. Fertilization trials probably caused some initial but not lasting response.

Table 1.--*Condition and trend studies on Gros Ventre River and East Refuge winter ranges*

Study	Year established	Location	Description
Individual species plots and charted quadrats	1920's	Livestock and game range on Teton Forest.	Several dozen quadrats established. Only a few relocated. No usable information.
0.75 acre (0.30 ha) exclosure	1939	Above Upper Slide Lake. E. ½, SE. ¼, Sec. 20, T. 42 N., R. 112 W.	Dismantled. Now within 360-acre (146-ha) Upper Slide Lake soil and watershed exclosure.
Canfield line intercept transects	1942	At three-quarter acre exclosure.	Sixteen transects originally—8 inside, 8 outside. All but 2 transects fenced within 360-acre (146-ha) Upper Slide Lake exclosure in 1960.
30x30 ft (9.1x9.1 m) experimental reseeding exclosure	1939	Above Upper Slide Lake; SE. ¼, S. 20, T. 42 N., R. 112 E.	Fenced within 360-acre (146-ha) Upper Slide Lake exclosure in 1960.
Camera stations	1939	At 1939 exclosures.	Seven camera stations; 5 at 0.75 acre (0.30 ha) exclosure and 2 at 30x30 ft (9.1x9.1 m) exclosure.
1 acre (0.40 ha) exclosure	1948	Coal Mine Draw. S. 28, T. 42 N., R. 112 W.	Exclosure in place.
Parker 3-step transect	1951	At Coal Mine Draw exclosure. S. 28, T. 42 N., R. 112 W.	Four transects inside and 2 outside exclosure. Not reliable for trend.
360-acre (146-ha) Upper Slide Lake soil and watershed exclosure	1960	Upper Slide Lake soil and watershed project. S. 20, T. 42 N., R. 112 W.	Exclosure in place. Elk and moose have entered periodically over drifted snow. Some use also by deer.
Parker 3-step transects	1954	Upper Slide Lake soil and watershed exclosure. S. 20, T. 42 N., R. 112 W.	Two transects. Discarded during 1968 screening for accuracy evaluation.
Camera points	1960, 1961, 1962	Upper Slide Lake soil and watershed exclosure. S. 20, T. 42 N., R. 112 W.	Forty-three photos taken from 22 locations within exclosure. Provide visual evidence of trend.
Parker 3-step transects	1951, 1954	Various locations on Gros Ventre River winter range.	Total of 19 transects. All are unreliable for determining trend.
3-acre (1.2-ha) exclosure	1960	On Forest east of Natl. Elk Refuge. S. 3, T. 41 N., R. 115 W.	Exclosure 3 has excluded ungulates since 1960.
Parker 3-step transects	1952	Same as above.	Nine transects inside and outside exclosure 3. Five determined reliable for measure trend. Three are inside exclosure, two are outside.
0.96 ft^2 (0.29 m^2) circular plots	1959, 1961, 1966	Vicinity of Alkali Cr. feedground. S. 23, T. 42 N., R. 113 W. Vicinity of Fish Cr. feedground. S. 12, T. 41 N., R. 112 W.	Ten transects of 10 plots each above Alkali Cr. Three transects of 10 plots each established in 1966 above Fish Cr. feedground. Not remeasured.
0.96 ft^2 (0.29 m^2) circular plots	1963	360-acre Upper Slide Lake exclosure.	Five transects of 10 plots each. Measurements 3-6 years after installation indicated no trend in bare ground or vegetal production.
3x3 ft (0.91x0.91 m) photo chart quadrats	1969	Coal Mine Draw locality S. 21 & 28, T. 42 N., R. 112 W.	Twelve quadrats placed randomly over an area of about 1 mi^2 in vicinity of and above Coal Mine Draw exclosure.

Gruell, George E.
1980. Fire's influence on wildlife habitat on the Bridger-Teton National Forest, Wyoming. Volume II—Changes and causes, management implications. USDA For. Serv. Res. Pap. INT-252, 35 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

Provides information on wildlife habitat condition and trend on the Bridger-Teton National Forest in the Jackson Hole Region of Wyoming by analysis of broad plant communities. Visual evidence of condition and trend are provided in volume I, The Photo Record. Management implications are included.

KEYWORDS: prescribed fire, burning succession, wildlife habitat, vegetation.

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